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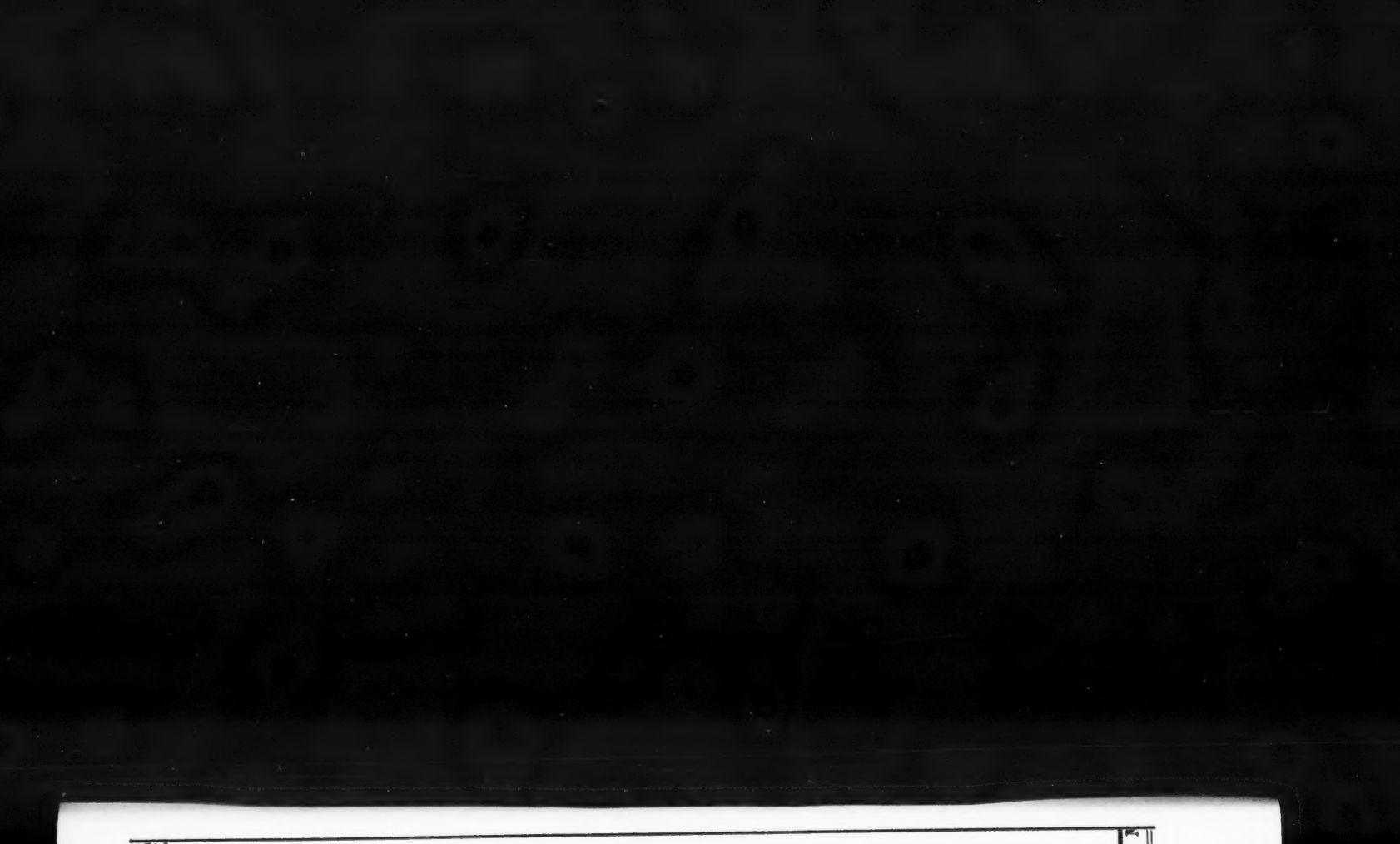

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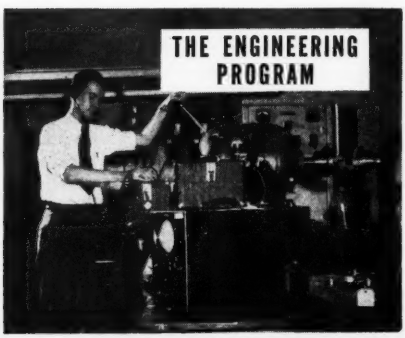

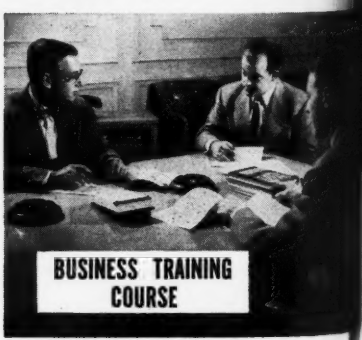

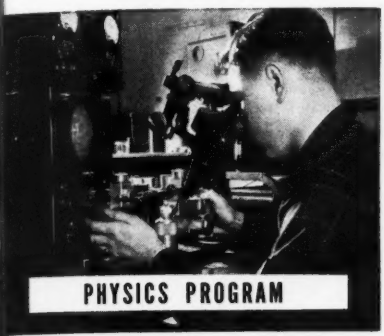

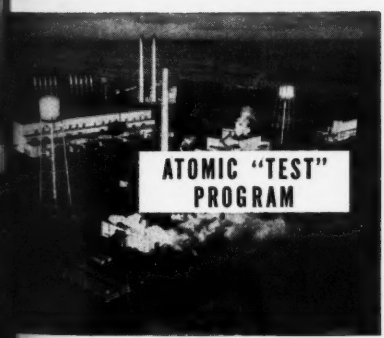

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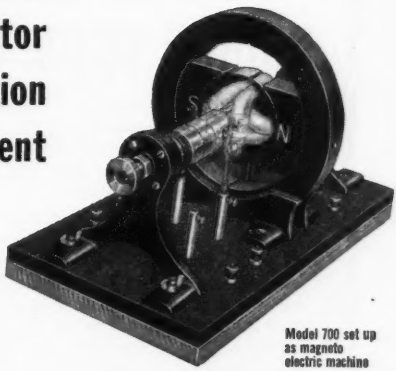

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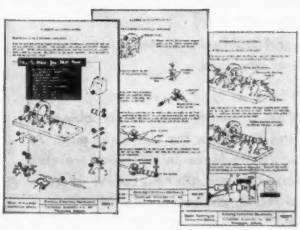

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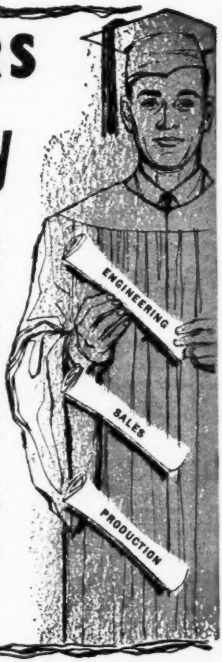

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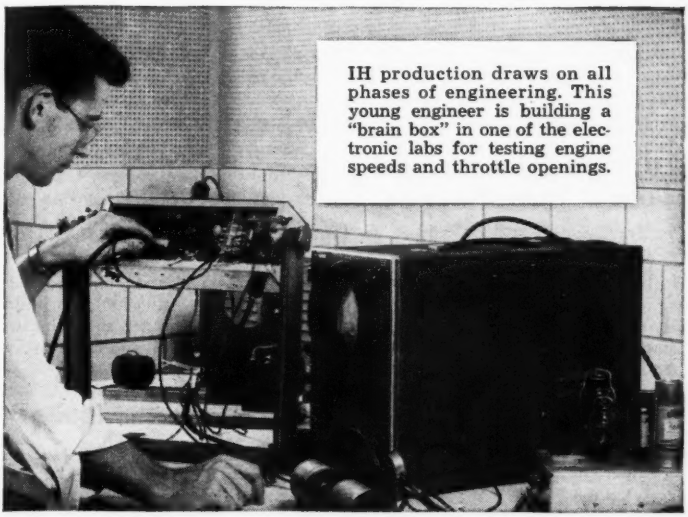

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How Much Research Should Engineering Schools Do?

By ERIC A. WALKER

Chairman, ECRC, and Vice President, ASEE, Dean, College of Engineering and Architecture, The Pennsylvania State University

Before World War II, schools of engineering did very little research; that which was accomplished was done by professors as an avocation or as some small projects done by the graduate students in engineering, and some small programs supported by such groups as the National Research Council and the Edison Electrical Institute. Engineering schools, like most industries and scientific organizations, really got into the research business during the war. Although a great deal of the research work was definitely of the applied kind, much of it was directed by physicists. Many engineering school staff members found themselves either in the Armed Forces, working in Government laboratories, or in industry during hostilities. It was not until near the end of the war that engineering colleges, through their experiment stations or research departments, got deeply involved in Government research.

It was expected that the end of the war would bring a relaxing of pressure on engineering schools to do contract research for both industry and Government. Such has not been the case, and with the coming of the Korean conflict, the volume of work being done by the engineering colleges was again increased. In 1952, this country spent nearly $3,000,000,000 on research and development. This is almost 1 per cent of our gross national product. Of this sum, $1,640,000,000 came from the Government, and most of the remainder from industry, with a small fraction from foundation and university funds. Of these funds, $280,000,000, was spent for research in the universities, $830,000,000 for research in Federal laboratories, while the remainder was spent in industry.

At the present time, according to the "Review of Current Research" of the Engineering College Research Council, over $65,000,000 * is being spent annually by its hundred-odd member institutions. This engages at least part of the activity of 13,000 faculty members and graduate students. The Directory itself covers 7500 projects which provide over 5000 separate entries in an index. The volume of research approximates the importance of student instruction as far as the number of staff members and the business offices are concerned. Recently, there has been much concern about the possible future of such research and development in the engineering schools. There is no doubt but that there will be a tightening of the military budget, and probably less money will be available for research anywhere.

As research funds are reduced by Congress, someone will have to take a cut. It is difficult to reduce the amount spent

* The apparent discrepancy between this $65,000,000 and the figure mentioned previously is that the $280,000,000 includes research in biology, psychology, and the other "soft" sciences, as well as the amount spent in large university laboratories (like Project Lincoln) which are operated by a university but not directly connected with the teaching function.

in Government laboratories because the level of effort is largely established by the facilities available and the ceiling on Civil Service positions. These "ceilings" have little current relationship to the operating funds and are not easily reduced. On the other hand, industrial research contracts are often associated with development and production, which affords an additional reason for not reducing research in industry. Therefore, many educators expect that the funds available for engineering school research will be reduced most sharply.

Research Tends to Become Programmatic

There are those who would regard this as a blessing in disguise. It is easy to recount the reasons why military research is not well-adapted to the college campus. Foremost, of course, is security. Even if a college decides to indulge only in fundamental and unclassified research, it finds that if important new results are obtained, the research, though still fundamental, has a tendency to become classified. Contractual difficulties are always present. The uncertainty of re-negotiation and the indeterminate length of contracts which still require the use of personnel with tenure are not conducive to easy and happy relationships between the college, the Government, and the professor. As has been pointed out before (1), Government and even industrial research tends to become programmatic. The research worker becomes a slave to a program and is not the scientific adventurer he would like to be.

Government programmatic research is not done without cost to the university, even though all identifiable costs are covered by overhead. Now at least one defense agency, in considering new proposals, has started to ask universities to identify their financial contribution to the support of military research programs before such proposals are considered.

Recently, hopes have risen that much of the basic and fundamental research previously supported by the military may soon be supported by the National Science Foundation. This change, if accomplished, may reduce the programmatic restrictions, but it will impose an additional financial burden on the colleges. In Department of Defense research, it is customary to pay for hidden costs in an item called "overhead," which usually amounts to about 45 per cent of the total sum paid for salaries and wages. Since salaries and wages, in general, run about half the contract expense, this means about 22 per cent of the total contract figure is paid to the colleges to cover hidden costs. In the National Science Foundation program, this overhead is calculated as 15 per cent of the total contractual sum. Such a contract thus immediately imposes a 7 per cent additional burden on the college if a program is moved from the Defense Department to the NSF. Additionally, the National Science Foundation prefers the college to provide the supervisor's time or salary and, if it is in accordance with the college's policy for other grants, to employ graduate students and remit the graduate tuition fees. These additional expenses are not inconsiderable, and most colleges could not afford to transfer all of their Department of Defense research to the National Science Foundation. However, against such difficulties one must balance the absence of security measures, the lack of the programmatic straight-jacket, and simpler accounting procedures.

These considerations again raise the question of why engineering colleges do research anyway. Many of us have leaped this hurdle by blithely and superficially quoting, "It is the duty of a college to advance the frontiers of knowledge." Engineers are not concerned only with advancing the frontiers of knowledge; they are concerned with producing machines, devices, and systems which will satisfy human needs.

Creative Aspects of Engineering Education

The major emphasis of engineering education is now turning to the creative

aspects of education. This dictum was first clearly expressed by Hollister (2) and it now is the main theme of the ASEE's Committee on Evaluation Report (3). Then, can one say categorically that if we want to teach our students to be creative, we ought to have a creative faculty? If the answer is "yes," it implies a faculty should be competent to take the results of research and create the new devices people want. This conclusion is the core of a policy statement now being discussed by the institutional members of the Engineering Research Council. If it is accepted, then all engineering colleges should have active research, development, and *design* programs.

The difficulties in constructing and managing a research program for an engineering college are many. There are many staff members who express a wish to participate in research and development but who have no idea of how to go about it. They are merely moths attracted by the candle. There are others who could spend days and years on problems which are of no importance. There is nothing wrong with this use of time if the pursuit of an insignificant question is an avocation. It may be as valuable a recreation as golf and tennis. The point is that an engineer shouldn't expect to be paid to do recreational research if it is pointless or without intrinsic value. The collecting of useless data has no engineering value.

Some would claim all data are useful and some day will be needed in an important engineering design. This is somewhat akin to drilling a hole in the ground just anywhere because one might hit oil. An engineer is expected to drill for oil where his data and reasoning tell him there is a substantial possibility of striking oil. Engineering research should be done in areas where there is an economic need for new discoveries.

Some teachers might work for years on a research problem and never produce a paper or a design which can be published or used. Therefore, most schools, even if they had adequate funds to support a fundamental research and development program, would not have a mechanism developed to use those funds efficiently.

Recently, the National Science Foundation, in attempting to find out what funds could be used properly in the engineering colleges, made a survey of the number of engineering teachers who were engaged in programmatic research and identified those who would prefer to pursue exploratory research and development programs if they had the choice (4). Such data are useful in setting the financial boundaries for research.

Funds Needed for Research

A different way to estimate the funds needed for research is to ask each faculty member how much of his time he would like to spend in creative pursuits *if* he could be relieved of an equivalent percentage of his teaching load. The danger in such a question lies in the fact that it is too easy to give an answer without any thought to what work should be done and what the final product might be. As a trial, the faculty of the College of Engineering and Architecture at Penn State was asked these three questions:

(1) What percentage (10, 20, etc.) of your time would you like to devote to creative engineering activities while being relieved of a proportionate share of your other duties?
(2) On what problems would you work?
(3) Where and in what form would you expect to publish the results of your research? (Be specific.)

The questions were prefaced by an explanatory statement intended to give the teacher pause so that he would think carefully before putting down an arbitrary percentage. The results of that survey are given in the following table:

No research or did not answer	54
10% time on research	5
12½% time on research	1

15% time on research	2
17½% time on research	1
20% time on research	31
25% time on research	6
27½% time on research	1
30% time on research	11
33⅓% time on research	3
35% time on research	1
40% time on research	2
50% time on research	12
	130

In the above table, all those who did not bother to reply were considered as having insufficient interest in research and therefore were recorded as zero.

A question then arises, "How much would it cost to put an adequate research program into effect?" There are a number of ways of calculating this, all susceptible to very large errors. However, one might clearly identify the conditions under which the calculations are made and then use the figures as a guide.

The questionnaire shows that 76 people out of 130 wished to participate (this excludes department heads and other administrative help). This means 20 equivalent full-time people are required to do the research indicated or to cover the teaching load of those who wish to devote part-time to research. This is 20 out of a total teaching faculty of 130, or approximately 15 per cent.

With a teaching budget of $750,000, this requires that funds available for salaries must be increased by $125,000. Since this covers faculty time alone, it gives the minimum possible increase.

Suppose we went one step further and assumed that in addition to paying for teachers' time during the academic year, we were willing to pay the man for two months' vacation time and provide adequate funds for equipment, supplies, communications, etc. This produces quite different and larger figures. The number who would engage in summer work is not the 20 full-time people, but all 76 who indicated a desire to do research in our institution.

These people would be paid for two months' summer work, so our figures look something like this: During the academic year, 20 full-time people at an average salary of $5750 equals $125,000. For the summer months, 76 people at an average salary of $5750 paid for two months equals $87,400. A reasonable amount for equipment and supplies might be $1000 each, giving a total of $288,400. This represents a 38.4 per cent increase in the academic teaching budget to support the desired research.

Further Extrapolation

Let's look at it one more way. Suppose that these calculations were based on the normal National Science Foundation method of financing. In cases like this, the National Science Foundation is pleased if the college can underwrite the salary of the professor during the academic year, but they do believe that it is desirable to underwrite the summer months and to pay salaries for graduate students who are doing work toward advanced degrees. Last year the average NSF grant in engineering was $6500 per year, and each one supported an average of 1.25 graduate students. If a similar program were adopted for the 76 people who have desirable programs, the cost to the college would be the $125,000 mentioned previously as needed to pay their salaries during the academic year. The cost to the National Science Foundation on these averages would be 76 times the average grant, or $495,000. However, this would provide for summer employment for all 76 of these people and would provide a means of support for 95 graduate students.

If these percentages, which were established on the basis of this very small sample, were extrapolated to all the schools, the National Science Foundation bill for research in engineering would be $26,000,000 per year to support the research programs of 4600 out of 8000 engineering teachers. This is enough extrapolation.

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College Notes

A short conference on New Developments in Structural Design will be offered at **Virginia Polytechnic Institute**, August 4 through 6, under the sponsorship of the Department of Applied Mechanics. The program will be of direct interest to all structural designers and architects of the region, and will be presented from a practical point of view. It will cover topics embracing the design of structures subjected to impulsive loadings such as those resulting from atomic blasts, the elastic and plastic behavior of the materials and component structural parts, and the elastic and plastic analysis of two and three dimensional structures. All speakers are well known throughout the engineering world for their contributions to research in their respective fields. It is the intent of this conference to reduce the time lag between the publication of such contributions and the use of such material by actual practicing engineers.

Pratt Institute will offer a program leading to the degree of Master of Industrial Design in the academic year 1954–1955. Candidates must have a bachelor's degree in design, architecture or engineering and show promise in advanced design and product planning. A total of 32 semester hours is required for the degree.

* * *

A graduate course in the application of nuclear energy to industrial uses will be offered this fall in the evening division at **Illinois Institute of Technology**, Chicago. It is designed for students who hold B.A. degrees in engineering and have completed differential equations. Registration for the course will be held from 6 to 8 P.M. on Friday, September 17, at 3300 Federal Street, with classes beginning the week of September 20.

Dependence of Engineering Leadership on Mechanics and Physics*

By L. E. GRINTER

President of A.S.E.E.; Dean of the Graduate School and Director of Research, University of Florida

Important discussions have been taking place on nearly all campuses of engineering colleges during the past year concerning the future trends in engineering education. Since these discussions relate primarily to the professional-scientific core of the engineering curriculum they center around the subjects of mechanics and physics. There could be no professional engineering without these subjects which encompass many of the fields of study and research commonly classified as the engineering sciences.

It is indeed worth while to take time to look into the engineer's responsibility for the advancement of knowledge. For the first two or even three decades of this century the engineer's responsibility for new developments was strictly limited to applications of science and to the development of the art of engineering. He completed the development of great suspension bridges as an extension of Roebling's art without adequately sensing his responsibility for learning more about bridge vibrations and pulsating wind forces. Engineers developed radio partially as an art, but when applications began to outgrow the extension of the art, physicists were of aid in establishing basic theories of wave phenomena which gave rise to electronics as we now find it in our curricula.

Physicists were busy in research in the fields of engineering science, i.e., dynamics, elasticity, plasticity, fluid flow, thermodynamics, heat transfer and electronics until their attention was drawn away by their overwhelming responsibility for guiding all the numerous studies and applications of modern physics. It seems evident that there is more work to be done in modern physics than all the talented physicists can do in our lifetime. Hence, to engineers has fallen the responsibility for furthering our knowledge in the fields of engineering science, and to a considerable extent this work lies within the realm of engineering mechanics. Either mechanics men must move the field of engineering science ahead or in many places it will remain stagnant and unfruitful.

Training for Leadership Tomorrow

The question that has arisen simultaneously in the minds of a great many engineering educators is what influence should this new responsibility of the engineering profession have upon the basic training of engineers? A second great influence, our growing responsibility for nuclear energy applications, enhances the importance of this question. Nuclear engineering is an accepted area of employment although we give it no specific place in our usual curricula. Within the area of nuclear engineering there are being studied, developed and rapidly placed into use hundreds of new materials and processes. Our graduates have had no contact with these new developments, and they can have none with the amazing developments

* Presented before the Mechanics Division, Annual Meeting of A.S.E.E., University of Florida, June, 1953.

that so clearly lie immediately ahead. Over and over we have to ask ourselves the following question: Are we really giving young engineers the basic training that fits them for leadership not today but a decade or a generation ahead? The extent to which our curricula resemble those of the 1930–1940 era contrasted to the extent to which engineering methods of 1975 will diverge from engineering practice today gives us some measure of present inadequacies in engineering education. It would be comforting to feel that this lag in the educational process is normal and natural, and that young engineers have always had to overcome such handicaps. This would be true if engineering and science had been passing through a natural evolutionary period of development. Instead, the greatest scientific revolution of all time took place with the development of nuclear power. Engineering as applied science did not feel this revolution as early as physics and several other sciences. However, engineering is now being strained to the limit to fulfill its obligation to apply nuclear power to both war and peace. Engineering educators cannot disregard these forces, which, with the persistence of gravitation, continue to draw engineering education in the professional-scientific direction. As engineering educators face the realities of the great influence that modern physics will soon be playing in the field of engineering applications, I believe they will insist that their professional-scientific students study nuclear physics and physics of the solid state at the undergraduate level.

Specialization

At present we are building considerable specialization in the art of engineering into the curriculum at the undergraduate level in order to justify the use of the professional engineering designations or specializations of civil, mechanical and electrical engineer. These specializations have less significance today than they had a generation ago when one could accomplish very little until he knew the specialized art involved. In the future even more than today we can expect the fields of engineering science to be more significant as fields of specialization than the professionally accepted groupings. Our approach to a solution to this problem is to forget the traditional requirements of a narrowly professional nature and to let the student acquire the degree with professional designation of civil, mechanical or electrical engineering largely upon the basis of education in the field of engineering science. At a group meeting of twenty mechanical engineers interested in the field of mechanics I publicly noted that all except two had been trained as civil engineers. This is strong evidence, I feel, that we are overly specialized in our restrictions upon the award of designated undergraduate degrees in engineering.

Clarify Conflicting Issues

The Committee on Evaluation of Engineering Education can go little further than to clarify the conflicting issues that are struggling to be recognized in engineering education. Traditionally our institutions fortunately are free to reach their own decisions. I do not foresee or urge an immediate radical change in the pattern of engineering education. I do urge a fuller consideration of the need for a much larger percentage of young engineers well trained to enter the professional-scientific side of engineering where they will use their talents to work with and to interpret the work of physicists, chemists and other scientists for the purpose of making appropriate applications and to contribute by their own research to the advancement of the engineering sciences.

In order to increase the precentage of such engineers we will need curricular adjustments at the undergraduate level with increased emphasis for particular individuals in the study of MATHEMATICS, PHYSICS, CHEMISTRY and the ENGINEERING SCIENCES. We will also need more care-

ful selection of new faculty members who will lead our institutions in the long term evolution of engineering education. If we recognize a shortage of science background in engineers today, one obvious aid is to pick faculty members whose training has emphasized the scientific approach to the solution of engineering problems. The result should be to strengthen the more scientific side of the engineering profession without loss in continuity of those magnificent contributions that the art of engineering has produced.

College Notes

A joint program in engineering and liberal arts between **New York University** and **Rollins College**, Winter Park, Florida, was announced by Dean Thorndike Saville of NYU's College of Engineering and President Hugh F. McKean of Rollins College. Under the arrangement, Rollins College students may, after three years, transfer to the NYU College of Engineering as juniors. On completion of the combined five-year program, they will receive the degree of bachelor of engineering in a particular branch of engineering from NYU. Meanwhile, Rollins will award the bachelor of science degree after the fourth year.

* * *

A two-week special summer program on Mathematical Problems of Communication Theory will be presented at the **Massachusetts Institute of Technology** from July 12, through July 16, 1954. Further information and application blanks may be obtained from the Summer Session Office, Room 7–103, M.I.T., Cambridge 39, Massachusetts.

* * *

Robert F. Bacher, Chairman of the Division of Physics, Mathematics and Astronomy at the **California Institute of Technology**, has been named acting dean of the faculty.

* * *

Ralph B. Wiley, distinguished member of the **Purdue University** faculty for 46 years, head of the School of Civil Engineering and Engineering Mechanics since 1937 and director of the Joint Highway Research Project since 1939, retired June 30. He will be succeeded by Kenneth B. Woods.

Report of Summer Institute Preliminary Conference on Nuclear Physics in Engineering Education

By R. W. HOUSTON, *Editor*
Asst. Prof. of Chem. Eng., Columbia University

The Summer Institute conferences on Nuclear Physics in Engineering Education are sponsored by the ASEE jointly with the American Institute of Physics and the National Science Foundation. For preliminary orientation prior to the open conference to be held at Northwestern University in September, a closed conference was held at Columbia University from April 22-24, 1954. To this conference came over 30 * engineers and physicists from industry, the national laboratories, and the universities to discuss the requirements of atomic and nuclear science in engineering education and the means for its introduction. That such a group should devote its time and effort to this topic bears witness to the values to be gained by close cooperation among physicists and engineers.†

Objectives

At the outset of the conference it was recognized that one aim was to emphasize that modern engineering education must build upon a firm scientific base. This thesis is, of course, sparked by the fact that much of modern technology has been built upon scientific and technological foundations rather than chance uninformed invention, and there is every reason to believe that this tendency will continue. Today nuclear technology looms as a factor of tremendous potential importance in engineering. From the industrial point of view, atomic energy now means largely power or potential power. It was thus inevitable that the discussion tended toward this area of activity. However, other areas of potential industrial interest in the atomic energy field were noted, such as "by-product" radiation to catalyze chemical reactions.

The desirability of including nuclear physics in engineering education was discussed from the viewpoint of engineers and employers of engineers engaged in various atomic energy activities. The requirements of non-atomic energy industries were not specifically analyzed, although such industries were not wholly without representation.

This discussion raised two immediate questions: (a) What is meant by nuclear physics?, and (b) For what kind of engineer is the evaluation to be made? It did not appear necessary for the conference to come to any formal conclusions on these issues. However, the discussion broadened out to include not only physics of the nucleus, but also those areas of modern physics which are and will continue to be pertinent to the engineering development of atomic energy. The conference took cognizance of the fact that much of nuclear reactor engineering, for example, is actually rooted in the field of atomic rather than nuclear physics.

There are several facets to the second

* A list of those in attendance is appended.
† Cf. R. J. Seeger, J.A.S.E.E. *44*, 285, 385; N. W. Dougherty, ibid., 401.

question. The discussion was limited largely to education at the undergraduate level, recognizing that some 80 per cent of engineering students do not pursue formal education beyond the baccalaureate, but that the balance who enter graduate work in engineering is and should be slowly increasing. This trend would undoubtedly be accentuated by an early exposure to the analytical and the research point of view as developed in modern physics. It was also recognized that in addition to the traditional engineering disciplines, the curricula known as engineering physics or engineering science should be kept in mind, as well as a curriculum in what has been called nuclear engineering. The formal conclusions adopted by the conference and stated at the end of this report, avoid reference to specific areas of engineering.

In making recommendations as to the means for introducing "nuclear physics" into engineering curricula, it was recognized that it is both impractical and undesirable to suggest that engineering schools conform to any arbitrary pattern. The conference restricted itself insofar as possible to the questions of content and level, concluding that local situations in each school dictate the actual courses and their sequence.

The Employer's Problems

With regard to the number and distribution of engineers needed in atomic energy work three facts should be borne in mind: (1) Companies whose normal manufacturing operations require predominantly one kind of engineer would be expected to have a proportionately high percentage of this type in their atomic energy division. This reflects the fact that the engineering disciplines do frequently overlap one another. (2) The type of reactor being considered, designed, or operated may have considerable bearing on the type of engineer best suited to work on it. For example chemical engineers predominate at Oak Ridge, and the homogeneous reactors there being developed are considered primarily a chemical engineering problem. (3) A large proportion of any nuclear power plant capital investment will be in power generation and distribution equipment of more or less conventional design. This will always require the services of "conventional" power engineers.

As an example, the Atomic Energy Division of Babcock and Wilcox was reported to have the following composition:

Mechanical engineers	28
Electrical engineers	3
Nuclear engineers	8
Physicists	3
Metallurgists	4
Marine engineer	1
Management engineer	1
Total	48

This group is actively engaged in work leading to the construction of an economical nuclear power plant. As used here, the term nuclear engineer signifies a man with a better than average background in mathematics, atomic and nuclear physics, and who has completed graduate work at the Master's level, or equivalent, with specialization in the field of nuclear technology as typified by that given at the Oak Ridge School of Reactor Technology.

This same firm estimates that their atomic energy division will double its size in two to three years on the assumptions that nuclear power will be economically competitive with conventional power sources in the United States within ten years (except in the natural gas belt), and that the Atomic Energy Act will be modified to justify private capital risk within one year. The distribution of engineers would remain about the same with the exception of adding about four chemical engineers and two civil engineers. On this basis, it was estimated that as many as 6000 new engineers would be needed in this country by the nuclear power industry as a whole in about five years time. The opinion of the other conferees, however, was that this figure represents an approximate upper limit and that the

probable rate of growth may prove to be somewhat less.

A more fundamental approach to the required distribution of disciplines is to consider the nature of the work carried out by engineers in the development of nuclear power. Engineering problems relating to reactor core size, quantity and kind of fissionable material, and shielding, for example, must be handled largely by theoretical physicists or engineers with a strong theoretical background. Problems relating to physical characteristics of materials at high temperature or subjected to high radiation fluxes may fall chiefly to the metallurgist. The selection of materials with an eye toward neutron economy is of interest to both of the preceding groups. The metallurgist may also be faced with problems in corrosion of solid fuel elements and structural materials. Both chemical and mechanical engineers may be called upon to deal with this problem, not only in the reactor proper, but also in associated heat transfer and chemical processing equipment. Engineering problems in the design of control rod mechanisms, fuel handling facilities, and remote control devices must be handled largely by mechanical engineers. Problems in removing the heat generated in the reactor may be handled by both mechanical and chemical engineers. Sound structural design may be the responsibility of civil or mechanical engineers. Electronics engineers are required for control and instrumentation problems while electrical engineers must be concerned with the ultimate generation and distribution of electrical power. Associated with any nuclear power plant will be a fuel separation facility which will largely be the province of the chemical engineer. Cutting across all these specialties will be the continuing need for research and development-minded engineers and what might be called engineering economists who maintain constant vigilance for better and less costly methods.

A representative from Oak Ridge stressed the fact that, although the divisional structure of the laboratory followed the usual scientific and engineering breakdown, i.e., chemistry, physics, metallurgy, chemical engineering, etc., the work is actually conducted projectwise. In this way, each man on the project contributes most effectively when he comprehends all the scientific and engineering problems related to his own specific work. In other words, liaison among divisions is essential at all levels and not just at the upper supervisory levels. It is difficult to avoid the conclusion here that such engineering teamwork must be benefited by a common educational experience in basic science taught from the research point of view.

Nuclear Physics Requirement

A representative of the General Electric Company emphasized that 85–90 per cent of the engineers actually engaged in reactor and reactor component design require only a descriptive knowledge of nuclear concepts, i.e., familiarity with the language and ability to use the numerical values required in their phase of the work. This group should know the elementary particles and their approximate masses, but not necessarily their quantum or wave mechanical properties. The meaning of cross section and variation of cross section with energy and temperature should be qualitatively clear. Such terms as isotopes, radioactivity, activation analysis, neutron chain reaction, fission process, neutron diffusion, neutron flux, criticality, and transients should have a clear cut meaning to this group, although the ability to carry out extensive quantitative calculations on these subjects is not required. This list, of course, is much abbreviated, but it is evident that such topics as relate to the theory of nuclear structure and nuclear reactions are not required by the engineers in this group.

Only 10–15 per cent of the engineers engaged in reactor design and development work require a quantitative working knowledge of atomic, nuclear, and reactor physics, so as to be able to derive the pertinent numerical values. These have

been called nuclear analysis specialists. They must be able to organize, supervise, and interpret the detailed calculations involved in reactor design and the experimental testing required to bring a project to fruition. It might be expected that the majority of ideas for basic improvements in reactors would stem from this group. The educational background of this group would generally include graduate level work.

The conference did not attempt to reach unanimous agreement on the employers' needs with regard to nuclear physics in engineering training, but substantial accord was apparent on the following points:

(1) The majority of engineers employed in the nuclear field do not require a detailed knowledge of nuclear science, but a qualitative knowledge is essential.

(2) Specialization in nuclear engineering problems as another major engineering discipline is not warranted at the undergraduate level. There is, however, no reason why one or two term courses in nuclear theory and engineering problems should not be made available to undergraduate engineers on an elective basis at some schools. More importantly, many problem examples in standard undergraduate engineering courses can well be taken from the nuclear field.

(3) The most important requirements of any engineer in the nuclear field are his knowledge of fundamental concepts and his ability to think both analytically and creatively, since the technology of this field is diverse and subject to rapid obsolescence.

The Educators' Problems

The third principle objective of the conference, the *means* of introducing nuclear science into engineering curricula, is primarily of concern to the educators. The means may be discussed in terms of curricula and course content. The conference deemed the latter its major problem and did not attempt to make specific suggestions with reference to specific curricula. It recognized, however, the existence, or potential existence, of curricula in the traditional disciplines, as well as in engineering physics (or science) and nuclear engineering. All of these usually have a common core of basic science and engineering subjects, most of which are included in the Freshman and Sophomore years, plus the opportunity for a small amount of elective work in the upperclass years.

The conference did *not* recommend that any material now normally covered in a general physics or chemistry course be deleted or removed to a later engineering course. It did recognize that many aspects of modern physics can be successfully interwoven with the subject matter of classical physics, and that a close correlation with the general chemistry course is undoubtedly necessary for a satisfactory solution to this problem. In some institutions, if the formal conclusion recommending an advanced course in modern physics is adopted, it would mean that some other course or courses may have to be revised or dropped, or electives removed. The conference did not presume to suggest what can be done in this situation, feeling that it was entirely a matter for the particular school to decide.

Introduction to Modern Physics

The subject matter of modern physics may be introduced in the engineering curricula in two places, the Freshman-Sophomore general physics course, and/or a special course in the Junior or Senior year. Summarized below are the recommendations of one of the educators present on the introduction of modern physics into the general physics course.

The general physics course is perhaps best placed when it is preceded by a sufficient amount of chemistry to make it easy to introduce the atom and its structure early in the course. It should also be preceded by a sufficient amount of mathematics that calculus may be employed. (A minority of those at the conference felt that this was not essential.) In me-

chanics, the traditional starting topic, molecules should be introduced in connection with elasticity. The Bohr Theory of the hydrogen atom can be one of the examples of the inverse square law of force. Intermolecular potentials can be introduced in connection with surface tension.

Kinetic Theory should be emphasized. (Most members of the conference were in strong agreement on this point.) This brings to the student's attention the statistical approach. The application of kinetic theory need not be restricted to the ideal gas development, but, through the concept of mean free path, should be applied to transport phenomena, the behavior of neutrons in moderators, electrons in metals, high vacuum production, etc.

The electron should be introduced at once in electricity. Emphasis can be on the Van de Graaff generator, the motion of charged particles in electric fields, and Millikan's oil drop experiment. The action of magnetic forces on currents and moving charges can include discussion of the mass spectrometer, at which point isotopes can be introduced, the cyclotron, and the synchrotron. Faraday's law of electromagnetic induction can be illustrated by the betatron. Limitations on the attainment of high voltages by transformer action can be brought out at this point.

In close association with the subject of electronics, in which scalers as well as amplifiers, rectifiers, etc., can be discussed, is the subject of quantum theory, the elements of which can be illustrated by photo and photo-multiplier tubes, X-ray production, and Geiger-Mueller counters. Use of the Bohr Theory to illustrate ionization potentials and the production of spectral frequencies can be an important means of introducing the concepts of nuclear structure.

Near the conclusion of such a course, the elementary particles, protons, neutrons, etc., can be further discussed, along with nuclear forces, mesons, radioactivity, fission, the mass-energy relation, and the principles of relativity, especially the increase of mass with velocity.

Demonstration of experiments should accompany the lectures, preferably using standard components but with large schematic diagrams for illustration. Laboratory experiments might include scintillation counting in a darkened room, measurement of radioactive half-life, neutron intensity about a paraffin moderated neutron source, and beta absorption measurements.

The conference recognized that there is a limit to the extent to which modern physics can be introduced into a basic general physics course and for this reason made the third recommendation given at the conclusion of this report. The level at which this material should be presented requires the use of calculus. The conference also noted that, where appropriate, approximate graphical and numerical mathematical procedures should be employed and the availability and use of automatic computing machines in making scientific calculations might reasonably be discussed. Close cooperation among the teachers of mathematics and physics, as well as engineering, thus is indicated.

Perhaps the strongest recommendation of the conference relates to the inclusion of atomic energy material into standard engineering courses. It was stressed, in particular by the engineers and physicists in industry and the national laboratories, that nuclear technology is closely related to almost every one of the conventional engineering disciplines and that adequate preparation in the fundamental concepts and methods of analysis in these fields is essential preparation for nuclear engineering. Many engineering problems can be drawn from the nuclear engineering field. For example, an engineer is better equipped to solve heat transfer problems in reactor design if he is familiar with the broad range of heat transfer applications in industry, than if he has simply been trained on the heat transfer problems in reactors. There are many reactor heat transfer problems which could easily be used as problem examples in the general field of heat transfer in undergraduate me-

chanical or chemical engineering courses. The effects of radiation on solids fits in quite properly in courses in metallurgy and engineering materials of construction. Remote handling equipment design problems might be included in mechanical engineering design courses. Chemical processing of radioactive and fissionable materials and isotope separation processes should furnish additional problem material in chemical engineering courses, covering the general problems of industrial-scale physical and chemical separations. Electronics instrumentation courses can show that similar principles apply to the design of instruments to monitor radiation and to control reactors as apply in the communications industry and in the new forms of industrial electronics.

This principle can be applied to both graduate and undergraduate engineering courses, although it may be possible to carry it a little farther on the graduate level. For example, a chemical engineering course in applied reaction kinetics might reasonably devote one or two weeks to nuclear chain reactions, the basic approach to the nuclear reactor design being essentially similar to chemical reactor design.

Availability of Nuclear Information

There are two important questions involved in carrying out this recommendation, viz. (1) the potential problem of security and classified information, and (2) the problem of engineering educators themselves becoming sufficiently well versed in the nuclear field to introduce examples taken from it. The majority of the conferees saw no real problem in security. A great deal of important information on methods and data has been declassified and published either in regular journals or as government documents that are readily and economically available. It was also suggested that if engineering educators show a greater interest in obtaining information for use in course work, it is possible that some of it might be classified more quickly.

The second problem, that of getting the information to the teachers themselves, is of more significance. This problem is not as important in institutions having staff members who have worked in the atomic energy field or who are engaged as consultants therein. For others, a few texts are now available, or will be in the near future.‡ Teachers wishing a more direct picture of the field may be able to obtain summer employment in one of the atomic energy installations, or admission to the one year course at the Oak Ridge School of Reactor Technology.§

The conference did not attempt to come to a definitive conclusion regarding specific courses, nor the content of courses in nuclear engineering and technology. Some members of the conference felt that it was highly desirable to have one or two-term courses available to upperclass engineering students on an elective basis. Others felt that a better alternative was the advanced course in modern physics mentioned earlier. No one expressed the view that nuclear engineering should be a discipline alongside mechanical, electrical, chemical engineering, etc. Most agreed that it was not inappropriate for some institutions to offer at least the possibility of a strong minor in nuclear engineering at the graduate level. The availability of appropriate staff personnel and laboratory facilities must dictate the solution at specific schools, of course, with an eye to the present and future needs of the industry.

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‡ For example, see: Glasstone, S. & M. C. Edlund, "Elements of Nuclear Reactor Theory," D. Van Nostrand, N. Y., 1952; Stephenson, R., "Introduction to Nuclear Engineering," McGraw-Hill, N. Y., 1954; Bonilla, C. F., ed., "Nuclear Engineering," McGraw-Hill, N. Y. (to be published); Goodman, C., ed., "The Science and Engineering of Nuclear Power," Vols. I & II, Addison-Wesley (1947); Murray, R. L., "Introduction to Nuclear Engineering," Prentice-Hall, N. Y. (1954).

§ For information, write to ORSORT, Box P, Oak Ridge, Tenn.

Conclusions

The following formal conclusions and recommendations of the conference were adopted without dissent at the final session on April 24, 1954.

"In view of the increasing role of atomic and nuclear phenomena in engineering, it is the sense of this conference that:

1. All *general physics courses* should give continual attention to the inclusion of modern physics material at appropriate places throughout the entire course.

2. All *engineering courses* should give continual and increasing attention to the inclusion of pertinent atomic energy material.

3. All *engineering curricula* should contain atomic and nuclear science material of a scope covered by a 3 semester-hour course at the junior or senior level (beyond general physics) including topics such as:

(1) Atomic Structure of Matter
  (a) Kinetic Theory
(2) Fundamental Particles
(3) Quantum Theory of Light
(4) Atomic Structure
  (a) Energy Levels
  (b) Spectroscopy
  (c) Periodic System
(5) X-Rays
(6) Wave Nature of Matter
  (a) One Dimensional Wave Equation
(7) Atomic Nucleus
(8) Molecular Structure
  (a) Valence Bonds
(9) Nuclear Structure—Elements, isotopes, elementary particles
(10) Binding Forces
(11) Binding Energy Curve
  (a) Mass-Energy Relation
  (b) Radioactivity
  (c) Nuclear Reactions
  (d) Fission, Fusion
(12) Neutron Chain Reaction
  (a) Heat—Power
  (b) Radiation—Interaction with matter
    Radioisotopes
    Breeding
  (c) Fission Products

4. In view of the rapid advance of this new field it is also the sense of this conference that all *engineering schools* should give continual attention to the possibility and need for professional education in nuclear technology, especially at the graduate level.

The conference recognizes that the realization of these objectives will vary with local situations. It is evident, however, by the very nature of atomic energy that their implementation can be achieved only through close cooperation of engineering and physics departments, as well as other science departments."

Conference Members

Clifford K. Beck, North Carolina State College
Clarence E. Bennett, University of Maine
Charles F. Bonilla, Columbia University (Chairman)
Lyle B. Borst, University of Utah
Joseph C. Boyce, Argonne National Laboratory
William M. Breazeale, Pennsylvania State College
Arthur B. Bronwell, Northwestern University (ASEE Liaison)
Harvey Brooks, Harvard University
George M. Brown, Northwestern University (Open Conference Chairman)
Robert A. Charpie, Oak Ridge National Laboratory
William H. Crew, Los Alamos Scientific Laboratory
Thomas B. Drew, Columbia University
John R. Dunning, Columbia University
Russell A. Fisher, Northwestern University
Henry J. Gomberg, University of Michigan
B. R. Gossick, Purdue University
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Clarke Williams, Brookhaven National Laboratory
Hugh C. Wolfe, Cooper Union
Frederick C. VonderLage, Oak Ridge National Laboratory
H. A. Wagner, Detroit Edison Company

Sections and Branches

A meeting of the North Midwest Section of the American Society for Engineering Education was held at Marquette University, Milwaukee, Wisconsin, October 10, 1953. Report of the Nominating Committee was presented and unanimously approved.

Chairman Drought reminded all division chairmen as well as all chairmen of committees to submit a written report on their committees and meetings to the chairman of the section for inclusion in his report.

Dean Kurt Wendt reported on the past year's activities of the national executive council including discussion of the following items:

1. The concern of the national council for the efforts of some groups toward the "unionization" of engineers and, in some cases, the establishment of student chapters of unions on campus.
2. The attitude of the national council toward the presence of commercial displays at the national conferences.
3. The unanimously granted honorary memberships of Dean H. P. Hammond and Dean A. A. Potter.
4. The proposal for an increase in members' dues which will be sought by individual ballot in the future.
5. The proposed joint venture on the part of the Relations With Industry Division and the ECAC Committee on Selection and Guidance to study the possible prediction of success of engineers.
6. A thorough discussion of the "First Resolution on Accreditation Adopted by the Committee on Evaluation of Engineering Education."

Industrial Summer Opportunities

By CLYDE E. WORK

Associate Professor of Mechanics, Rensselaer Polytechnic Institute

and HAROLD P. SKAMSER

Chairman of Engineering Placement, Michigan State College

It is widely recognized today that the most effective engineering teacher cannot be developed and nourished on book knowledge and contemplation alone. Direct first hand activities in the industries in which his students are to be engaged offer a means of broadening his professional perspectives for both teaching and counseling.

There is only one practical way for the college faculty member to get this viewpoint reliably, that is to work for several companies in each of several industries. Ideally, he will have worked in different departments of different companies and each of these engagements will be of sufficient duration to enable him to acquire a feeling for the operation; i.e. an understanding of what was going on, both in the technical operations of the company as well as in what can be called the psychological or personnel-management side. Obviously, any approach, no matter how remote, to such an achievement would require exceptional cooperation and understanding in the industry making the opportunities available to large numbers of the college educational staffs of the country.

Although no such goal has yet been reached, some far sighted industrial leaders have taken the initiative to do more than their share in this effort. Their conscious efforts have been in the direction of offering short term employment, of men in the teaching profession, in their own industries or inviting educators to participate in joint conferences, seminars and discussions of mutual problems at the expense of the host industry. Some such programs are on a leave of absence basis but those available to the largest per cent of the professors are offered during the summer vacation period.

Some of the opportunities which summer employment in industry can make available were discussed by the authors in a previous article.[1]

It is the purpose of this article to describe what some other industrial groups are doing in the same general effort. It is recognized that the programs included here are not the only ones, but it is felt that they are representative of the best of today's opportunities in this area.

General Electric Company

Professors Conference: This program was initiated in 1937 and each summer approximately twenty-five engineering educators from all over the country, ranking from instructors to deans, are invited. Fields represented usually include mainly electrical and mechanical engineers with a few industrial engineers. The five week program includes three weeks during which time the visitors work on a specific assignment in one of the company's plants and a two week formal program of conferences,

[1] Summer Employment—Boeing Style, JOURNAL OF ENGINEERING EDUCATION, Vol. 44, No. 9, May, 1954.

seminars, lectures, tours, social activities and recreation. Many top level company personnel participate in presentations of various phases of the company's operations, discussions of opportunities for engineers within G.E., development of the engineer, evaluation of his performance and other pertinent topics.

Teaching Methods Seminar: This is a one week program sponsored jointly with the A.S.E.E. to which about twenty-five young engineering instructors with a wide variety of academic interests, and distributed over the nation, are invited to study in Schenectady the educational teaching techniques used in G.E.'s Advanced and Creative Engineering Programs and evaluate an application and the effectiveness for undergraduate academic teaching. Participants receive only expenses but in addition to planned technical sessions hold informal discussions, plant tours and limited social activities.

Informal Summer Employment: More than thirty engineering professors were employed on individual work assignments during the summer of 1953. The number any given summer depends on the specific projects lending themselves to short term assignments. In 1953, during the month of July, a technical lecture program consisting of a series of nine afternoon sessions of an hour and half each, were arranged for these men. Topics considered pertained to various phases of technical interest within the scope of the company's activities and were presented by G.E. personnel.

A few organized plant tours were arranged and individual tours could be requested. One or two minor social events were held in 1953 and it is hoped to extend this area in the future.

International Harvester Company

Program for University Faculty Members: A three week summer conference has been held annually since 1949 to which the company invites ten to twelve colleges to send faculty members representing specified departments. The purpose of the program is to acquaint educators with Harvester and its philosophy and to gain from the observations and opinions of the educators.

The first half of the program consists of conferences with top management and plant tours. During the second half, participants carry on individual study in the phase of operations related to their own field of interest. Visitors are invited to all regular sessions of the Executive Council, and committees of the company meeting during the conference period.

Informal Summer Employment: Opportunities for full summer employment on a specific project are on an individual basis depending on the needs developing in the various departments and plants.

E. I. DuPont de Nemours & Co.

Year in Industry Program: The company has developed a program offering a year in industry for three engineering educators each year. Men with academic administrative duties under the age of 55 are eligible for selection. The purpose of the program is to give the educators broad understanding of the DuPont Engineering Department, to aid industry through the students and to improve college-industry understanding.

Compensations equivalent to normal college earnings plus an allowance for travel are offered while the professors visit and study all divisions of the engineering department. Visitors discuss organization and management with top level management, operations with middle management and the problems of newly employed graduates with the graduate himself. They visit various plants under construction and in operation and have the opportunity to learn the details of any engineering job of particular interest from the man who does the job.

3-Week Symposium: The DuPont Company also conducts a symposium planned particularly for social scientists

in which executives discuss business philosophy and methods with guests. A series of plant tours are also arranged for participants.

Monsanto Chemical Company

Industrial Leave Program: The company invites a college faculty man, hitherto inexperienced in industry, to spend an academic year with them.

Summer Employment: A variety of assignments in departments of the company such as production and engineering develop for assignment to faculty members interested in summer placement. Efforts are being made to enlarge the scope of this program.

Bell Telephone System

Short Conferences: Bell sponsors short conferences for faculty members lasting a week or two on specific activities. In the summer of 1953, the Bell Laboratories had representatives from colleges all over the country, discussing new developments in computers. The Michigan Bell had a one week conference in August, 1953, on the economics of the utility.

Summer Employment: Western Electric, Bell Laboratories, Sandia and other divisions of American Telephone and Telegraph Company hire faculty members during the summer months for specific assignments. However, during these intervals the faculty members are given ample opportunity to visit other departments and talk to specialists in other fields. An executive with the Bell system indicates that they are aware of a need for a more formalized program of summer faculty employment.

Conclusions

The faculty members participating in industrial programs such as the ones described here are enthusiastic as to the benefits derived and the desirability of broadening the scope of opportunities available. Sponsoring companies express satisfaction and sense a need for continuation and expansion of programs of the types described.

A sub-committee of the YET group in ASEE has initiated a project to encourage participation of faculty men, particularly the younger ones, in these programs, to encourage other industries to establish such programs and to encourage companies already doing so, continually to reexamine and improve their plans so that through combined efforts and participation, the quality of the graduating engineer who is the end product of our schools and one of the raw materials for industry will continue to improve.

The authors do not recommend any uniform plan as an ideal program to be offered by all companies or claim that one type of program meets the need of all faculty members. It is, rather, encouraged that each industrial group begin or continue to experiment with ideas to fit their own situations but which will contribute to the overall success of those professionals charged with the responsibility of training the engineers of the future.

Engineering Curricula—Then and Now

By ELMER HUTCHISSON

Dean of the Faculty, Case Institute of Technology

The first reaction of an old grad when he sees the study program of the boys now in an engineering school is "Jeepers, I sure am glad I didn't have to study that stuff when I was in school—I never would have graduated!" Actually, however, present students don't find their studies any more difficult than did the students of twenty-five years ago. If we look back at the records we find that in many schools higher average grades are being given now; moreover, the work loads in terms of contact hours are considerably lighter. We must remember that our modern student has grown up in a world in which the vacuum tube, the mechanical brain and the jet plane are commonplace—so much so that an old-timer nowadays has a hard time even following the adventures of Dick Tracy or the other heroes of the "comic strips."

A comparison of a typical curriculum of today, such as that in mechanical engineering, with one of two or more decades ago, shows not only a new terminology associated with the atomic age but also a new philosophy. Engineering no longer needs to depend upon empirical data and empirical methods to the extent it did some years ago. We all remember our courses in applied mechanics where we would calculate stresses in a beam to three (or more!) significant figures with our slide rules and then multiply by a factor of four or five which our instructors called "a factor of safety" but we with more wisdom than we realized called "a factor of ignorance." We know now that few aeroplanes could get off the ground if we couldn't calculate stresses more precisely than we were able to in those days. In fact, because of our ever-increasing desire and need to use materials more efficiently in this competitive world, detailed stress analysis has, in spite of its complexity, become an important phase of any course in engineering mechanics.

This same trend toward more detailed mathematical analysis is taking place in other engineering fields such as fluid flow, thermodynamics, electrodynamics and even in production engineering where motions are timed to thousandths of a second. To some, the course work may seem to be growing constantly more complex but actually the opposite is happening since broad generalizations are being substituted for a mounting mass of observational data which would need to be included in our curriculum if we did not place our main emphasis on fundamental laws. We will return to this emphasis on fundamentals later, but it will be well to compare in Fig. 1 the combined amount of time devoted to fundamental science and engineering in the 1953–54 mechanical engineering curriculum at one par-

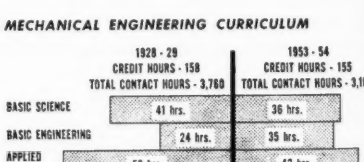

FIG. 1. Comparison of a typical mechanical engineering curriculum of 25 years ago with that of the present.

ticular college with that appearing in the 1928–29 curriculum.

Educational Problem

This brings us to an interesting educational problem—how do changes in college curricula occur? Of course, the main responsible body in most colleges is the Board of Trustees but the Board usually delegates all matters relating to the curriculum to the faculty. Minor changes in the curriculum are occurring regularly but often a complete revision of a curriculum is undertaken. On these occasions a rather small faculty group usually proposes a change and then after considerable study, consultation and debate the faculty formally adopts a new curriculum. The administrative staff of the college, as well as the faculty, has constantly to be on the alert to prevent any curriculum from becoming out-dated. To carry out this responsibility some guiding principles are needed that will enable one to judge which of two curricula is better.

Guiding principles in education cannot, unfortunately, be separated from one's personal philosophy of education. There have been numerous books lately by such eminent educators as James B. Conant and Robert M. Hutchins on the kind of higher education required in a free society. Fortunately, the problems in engineering education are much simpler than those in the liberal arts field, but this does not imply by any means that there are no problems.

For example, we like to ask ourselves, can we not design a perfect curriculum—if not perfect, at least, a better one than the one we had when we were in college? As we pursue this question further, another inevitably arises. For whom should the curriculum be better? Is it for the young man who pays his tuition? Or is it for society? The public-spirited men of the past who provided classrooms and laboratories and the endowment which continues to pay a substantial portion of the college operating costs, certainly were making their contributions to society generally rather than to the particular individuals who are admitted to the freshman class. The state itself makes a contribution by waiving all taxes. In addition industry is presently making a significant contribution to the operating expenses of many colleges.

All of this is as it should be. Society, like industry, finds it expedient to plow back into education a share of its profit as an investment for its future. In the early days society relied almost completely on education for the ministry. Later, education for the law and for medicine came in for a large share of the public interest and public funds. Only recently, with the clear dependence of our standard of living and even our national security upon advances in science and technology, a new interest in well-planned technological education has arisen.

Responsibility to Society

In planning a curriculum for an engineering college, perhaps the distinction just made as to whether our responsibility is to society or to the student loses its significance if we plan far enough ahead. For example, if we should design our curriculum so that our student can command maximum salary immediately upon graduation we should very likely come into conflict with our responsibility to society. On the other hand, if we aim at a curriculum which prepares a young man to be of maximum usefulness in a dynamic society throughout his life then there can be little doubt that he will receive adequate financial and other rewards from that society.

New questions arise in our minds. Can we recognize clearly the characteristics which we would like to see developed in our young man so that he will be useful in present-day society? Can we be sure also that these same characteristics will be valuable in the society which we will have some twenty to thirty years hence? If we can identify those characteristics which are likely to be useful, no matter how either our young man or society de-

velops, we will have a sound basis upon which to design the curriculum.

In seeking those characteristics which should be of value for all time in a dynamic society a few needed characteristics, upon which we will all agree, stand out. First, there are moral and ethical qualities—we must assist our young student to develop a high sense of personal integrity, a sense of kindliness, an ability to work with others and a confidence in himself which will enable him to assume leadership. Next, he must have a thorough knowledge in his technical field of those fundamentals which are themselves timeless and which have wide applicability. So that there may be time for these principles to be thoroughly learned in his undergraduate college years, specific applications to special processes must be left to later experience in industry or to graduate work. Also we expect any well-educated man to have a reasonable knowledge of history and the background of his own culture. Finally, and far from least, he must be able to communicate to others his ideas and his convictions and to receive theirs.

In analyzing those qualities which we want in each of our graduates, they seem to fall into two main categories. There are those which are taught by regular classroom and laboratory methods and those which, in this sense of teaching, cannot be taught at all. For example, one can't teach integrity or leadership by classroom methods and yet we all agree that these qualities are of utmost importance. Usually we separate out those subjects which can be taught and organize them into a formal sequence and this is what we call the curriculum. Progress in curricular subjects is measured at regular intervals and generally is the sole criterion for scholastic advancement.

How can we measure progress in the less tangible but ever so important characteristics such as integrity, kindliness and the ability to lead? Unfortunately, we have no way of making precise measurements but the faculty can and is definitely expected to do much to develop these qualities by setting examples to the students both inside and outside the classroom. Further, there have been set up what are called the extra-curricular or co-curricular activity programs which are in essence laboratories for developing human relations. It is just as important that the extra-curricular program be organized to carry out our fundamental educational goals as it is for our curricular program. This, however, is another story and in spite of its great interest we will restrict ourselves here to the academic course structure which we called the curriculum.

Two Kinds of Knowledge

In considering those subjects which make up the curriculum, we find that there are two essentially different kinds of knowledge each of which has its own teaching methods. The first of these includes such subjects as mathematics, the natural sciences, basic engineering and parts of history. This knowledge is generally called accumulative. The second kind of knowledge includes such subjects as politics, art, music and other areas closely tied in which human relations. These subjects have been designated as non-accumulative, although in many respects this is a misnomer. Dr. Conant, the former president of Harvard University, has suggested a test for distinguishing between accumulative and non-accumulative knowledge. Essentially his suggestion is that those subjects for which there exists reasonably uniform agreement as to what constitutes progress are called accumulative. Parenthetically, in these areas there exist also criteria for discarding obsolete knowledge. Such a field as mechanics certainly meets this test where all would agree that Newton's work represented progress over Galileo's and that Einstein's theories represent an advance beyond Newton's.

A prime example, on the other hand, of the non-accumulative field is that of art where there seems to be no agreement that Picasso or other modern artists have ad-

vanced beyond Michelangelo. Likewise, can there be any agreement that modern music represents progress as compared with so-called classical music or that we made much progress in our knowledge of how to prevent war? In fields such as these our stockpile of knowledge has been constantly building up over the centuries because we have no way of knowing which material can be discarded and which must be kept. We have accumulated less certainty but an awful lot of uncertainty. This makes the task of selecting material and teaching in these areas especially difficult.

Non-accumulative Knowledge and the Case Method

Let us now consider the procedures which seem to be most effective in teaching non-accumulative subject matter. An educational example in which there has been much experimentation is that of teaching decision-making in courses of business management. What one would like to do in such a course is to provide, within a limited period of a few months, the variety of experiences which one might get in many years of business. To do this one prepares a sequence of "case histories" which describe in considerable detail situations which have occurred in business. All of the facts and personalities involved are included and the case is presented to the class for extensive discussion and each member of the class is expected to make an appropriate decision and in some cases expected to justify his decision to the class. Through this case method, the student acquires vicariously in a relatively short time experience which he could only get in actual practice over a number of years. The case method has been given extensive trial at the Harvard School of Business Administration.

The case method undoubtedly has wide applicability in an academic curriculum and needs to be further developed. It is the one opportunity that we have of compacting the subject matter in non-accumulative areas of knowledge and thus making our teaching more effective. Some schools are presently using this method in courses such as surveys of American democracy and of western civilization. In these courses the instructors attempt to engender in the student strong convictions about the society in which he is living and his responsibilities in preserving our freedoms. Another area in which the case method is being given a thorough trial is that of machine design. Recently a week's conference was sponsored by industry to explore improvements in machine design teaching which are possible by the more extensive use of the case method or as it was called in this conference the project method.

The perfection of the case method of teaching and a recognition of its advantages in some areas of learning and its limitations in others are rather recent educational developments. It is a powerful teaching tool which has a definite place in our educational curricula and accounts for some of the changes which have occurred in engineering curricula in the past two decades.

Let us now look at the other broad area of knowledge that goes into our curriculum, that which we have called accumulative. Are there general principles that will enable us to improve the effectiveness of our teaching in this area? Are there also ways in which our curriculum should be modified so that engineering graduates will continue over the next twenty to thirty years to take the leading role in industry and in the community that they have in the past?

At least one answer to the first question appears from a closer examination of the nature of accumulative knowledge such as mathematics, mechanics, thermodynamics, etc. As implied earlier, an outstanding characteristic of these subjects is that they have been greatly compacted through the elimination of obsolete subject matter and through broad generalizations so that a college sophomore today can learn in one year to solve problems in mathematics or in mechanics that would have stumped

even Newton in his lifetime. In this compacting there has occurred an ordering process such that the more simple parts of the subject can be identified and learned first. In building a curriculum, advantage can be taken of this characteristic by a more systematic arrangement of the subject matter within a course and by the logical combination of the individual courses. Obviously, the student should not be permitted to advance to more complex material until the early parts are mastered. This condition is relatively easy to fulfill for the accumulative subject matter because understanding can often be tested by the student's ability to solve problems which have solutions which are definitely right or definitely wrong. Unfortunately, the same is not always the case with subjects in the non-accumulative field.

Accumulative Knowledge

The bulk of the purely technical subject matter taught in an engineering school is of the accumulative type. It is for this reason that so much emphasis is placed on mathematics, physics and chemistry in the student's first year. Throughout his four years the student builds upon these fundamentals. He cannot possibly learn special applications in this short time so that if he is to continue to be able to grow after college, he needs to be unusually well-grounded in these basic areas. The fact that engineering is constantly becoming more analytical means that the emphasis on basic science and basic engineering must be continually increased. This is borne out, as was mentioned earlier, in the comparison of the 1928–29 and 1953–54 curricula in mechanical engineering. It will be even more apparent if one visits a modern mechanical engineering laboratory and sees the maze of vacuum tubes, electronic circuits and precise measuring equipment which is becoming part of the engineer's stock in trade.

The fact that so much of the subject matter of engineering is accumulative explains the difference in the number of electives in the engineering curriculum as compared with that of a liberal arts college. When one is studying primarily non-accumulative subject matter it does not make very much difference whether one subject or another comes first since one subject does not as a rule build upon another. Also because of a lack of compacting, such as occurs in science or engineering, there is tremendous variety of subject matter to choose from. Since no one can say that one subject is more important than another, the choice is left to the student. Just the opposite occurs in engineering. If one decides to select a given branch of mechanical engineering, each course fits into a pattern which leads the student from the simple to the complex over a four-year period and very little can be left to the choice of the student.

Because time is so limited in the engineering curriculum, an attempt has been made in the teaching of the humanities and social studies in at least one engineering school to achieve some of the advantages which come from the compacting in the accumulative areas. The discussion method is used almost exclusively but great care is taken in the selection of the subjects for discussion and they are brought as far as possible into an orderly array within a four-year integrated program. This procedure gains ready acceptance among students used to the rigor and logic of engineering courses, and engineering schools have an unusually good opportunity of making a real contribution to teaching effectiveness in this area. The programs now underway are drawing national attention and support and may well be used as a pattern for the teaching of these subjects in other engineering schools and perhaps even in the liberal arts colleges.

The Art of Communicating Ideas

There is one further characteristic that we listed as being essential in a well-educated person. This is the ability to interchange ideas freely with other peo-

ple. We like to start our instruction by being sure that our student can read quickly and with full comprehension. In some schools, tests are given to the entering freshman and if he is a slow reader, he is sent to the reading laboratory where with the aid of optical-mechanical devices he is taught to increase his reading speed sometimes as much as two or three times what it was originally. Next he is given instruction in clear, concise and effective writing. Later he is given training in oral expression, not only in debating but in the simple natural use of one's speaking ability to get ideas across to individuals or to groups. The engineering student is taught principles which he will have ample opportunity to test and apply throughout his four years in college and, in fact, throughout his entire professional life. One additional tool of effective expression is often developed in the engineering curriculum. This is the use of the graphic arts to assist in the communication of ideas. No longer can an engineer be satisfied with the use of blue prints to get his ideas across. Instead he must be able to write clearly, speak forcefully and use all manner of charts, sketches, diagrams and pictures to sell his ideas to others.

Summary

Thus we see some of the differences in the curriculum twenty-five years ago and today. The present curriculum is more concentrated with greater emphasis on fundamentals both in science and in engineering. The curriculum is broadened by the inclusion of carefully tailored overall programs in the humanities and social studies and by placing great stress on the development of the ability of communicating ideas effectively to others. Sight is not lost of those invaluable qualities of personal integrity, kindliness and leadership and a determined effort is made to develop these throughout the entire curricular and extra-curricular program. The perfect curriculum is still a dream but there is a growing conviction that a good broad technological education is the best general education that society can offer.

Opportunities for the Civil Engineer in the Atomic Energy Industry and the Resultant Challenge*

By E. F. GLOYNA

Associate Professor of Civil Engineering, The University of Texas

A prominant engineer in the atomic energy industry has said, "The Civil Engineering Profession in general and Sanitary Engineering in particular should be much more active in the new atomic energy industry both in obtaining a proper evaluation of their interests and in appraising their opportunities and obligations."[1] His statement might further imply that the development of the atomic era is dependent upon the combined efforts of all professions; for each professional group has its obligations in the productive peace-time development of atomic energy. Those professions which fail to evaluate their obligations can expect the opportunities to be absorbed by the more informed and energetic organizations. Engineers therefore should re-evaluate their educational and professional status with regard to this new development.

Civil Engineers are potentially capable of contributing much to this combined scientific and technical endeavor, and are particularly needed in matters involving:

1. Selection of plant sites for nuclear reactors and associated units.
2. Design and construction of special structures and facilities.
3. Research in all phases of civil engineering.
4. Development dealing with water purification, waste disposal and environmental sanitation.

The opportunities for civil engineers in the atomic industry are real; but only those engineers who broaden their knowledge to include these modern scientific developments may actually benefit. Accordingly, civil engineers should have a fairly complete understanding of the basic sciences, particularly introductory nuclear physics. The reasons for and methods by which the civil engineers may keep abreast of modern developments can best be exemplified by expanding upon the four major endeavors stated in which the civil engineer may be used.

Site Selection

The first opportunity for contact between civil engineers and the atomic energy industry is in plant site selection. The choice of nuclear reactor sites is really a cooperative venture between management, engineers, geologists, stream biologists, meteorologists, health physicists and defense personnel. Because of possible surface, ground water and atmospheric contamination by radioactive isotopes, the geologists, meteorologists and stream biologists are key members of the site selection team. The heal-

* Paper presented to the Student Section, American Society of Civil Engineers, The University of Texas, August, 1953.

[1] Gorman, A., "Learning to Live with Atomic Radiation—A Challenge to Engineering Profession," *Civil Engr.*, **824**, 28 (Dec. 1949).

physicist and disaster-defense team may also exercise considerable control over the actual selection because of the necessity of area-radiation hazard control. The desirability of broader knowledge on the part of civil engineers is further emphasized by the fact that the usual yardsticks of water, fuel, transportation and labor resources are not the only criteria for the judicious location of atomic power units. In this connection, appropriate professional decisions may be made by combined interests if each group concerned draws from a reservoir of common but basic scientific knowledge.

Design and Construction

Many civil engineers are employed by the Atomic Energy Commission (A.E.C.) in conventional capacities. The number of civil engineers required is necessarily large since the A.E.C. projects are tremendous as compared with the average endeavors of industry. The cost of the original Oak Ridge establishment, plus the city of Oak Ridge, was over one billion dollars. One of the newer gaseous diffusion units at Oak Ridge cost over one-half billion dollars; and to operate these units the world's largest steam-generating, electric power plant had to be constructed. The need for this additional power, even though Oak Ridge is in the midst of the Giant Tennessee Valley Authority, illustrates the immensity of the atomic energy projects.

In addition to the conventional problems in design and construction, new problems have been introduced by nuclear reactors and allied facilities. Never before has the engineer been called upon to design radiation protective devices that permit the handling of thousands of curies. (Until the atomic era came into existance only a few curies of radium were available to industry.) Some of the essential protective measures are attainable through the use of specially prepared dense-concrete, or through the use of pneumatically operated tunnels or water-filled canals. These tunnels and canals are vital in facilitating the transporting of "hot" radioactive batches. Another example of the necessity of special design is demonstrated by the inadequacy of ordinary designed centrifugal pumps and electric motors. The commonly used packing and insulation become inoperative when centrifugal pumps and electric motors are subjected to neutron bombardment. Furthermore, once this equipment has been subjected to high levels of radiation, remote control measures must be available to facilitate repair.

These special features and many others too numerous to list are sufficient reason for the engineer to expand his fundamental knowledge of materials through research.

Research

From the few illustrations which have been given it is evident that the engineer has more than just a fleeting responsibility in the field of basic research. To emphasize this challenge, reference need only be made to a policy statement of the National Manpower Council, "That there is now a shortage of physicists with all levels of training to assist in translating new scientific developments into the field of engineering. This shortage can best be relieved by providing additional mathematical and basic scientific training for engineers." [2]

Several Atomic Energy Commission installations have sanitary engineers to direct the research and actual disposal of liquid wastes. In these installations the sanitary engineers have maintained close contact with the physicists, radio-chemists and stream biologists. Although much credit is due the sanitary engineers who have undertaken some of the basic research, much more research and work should be carried out before the techniques and efficiencies measured in terms

[2] "A Policy for Scientific and Professional Manpower," prepared by the Research Staff of the National Manpower Council, New York; Columbia University Press (1953).

of activity removal and costs can be definitely determined.

Water Treatment, Waste Disposal and Environmental Sanitation

Process water, used water and its associated health implications in the nuclear industry are of such importance that the future of atomic energy in commercial industry may well hinge upon the ability to handle the waste products economically.

In many respects, nuclear fission operations start as do many other industrial operations. Raw materials, primarily uranium ore, must be crushed, screened, refined and finally exposed to high level neutron bombardment. During this bombardment some of the uranium atoms split, resulting in the liberation of energy and formation of different radioactive elements. Some of this energy is released in the form of heat which is usually controlled by air or water. In either case the large quantities of coolants become contaminated and are potentially hazardous. The technical control required for the treatment of coolants must be of the highest order to reduce the degree of contamination.

Wastes from nuclear reactors include the usual liquid, dry and gaseous products. Dry wastes are canned and buried, while the finely divided particles in gaseous streams are separated from the fluids to the point where atmospheric dilution is possible. Liquid wastes are more of a problem. As an example of the potential hazard envolved, one gram of Sr^{89} (a product of uranium fission) in 100,000,000 gallons of water could cause the tolerance value for ingestion to be many times above the Maximum Permissible Allowable (MPA) tolerance value for liquid ingestion. MPA values are important guide posts; and frequently treatment, together with dilution, produces a resulting solution which is not harmful for human consumption.

On the other hand, MPA values may be as misleading as "Handbook" data in the hands of the uninformed. Suppose that after adequate dilution the isotopes in question are again concentrated by plankton. Since fish feed upon plankton, a serious set of circumstances might arise when the fish are in turn consumed by people. The environmental phase of radioactive control, therefore, dictates that engineers not only think of physical, chemical, bacterial or biological terms but broaden their scope to include radioactivity.

Conclusions

The rapid use of radioactive isotopes by industry in general, hospitals and research organizations, is an awakening example of the need for the civil engineer to keep pace with modern developments and to accept his part of the responsibility. Every phase of engineering and science will be in contact with problems posed by the wide-spread uses of radioactivity, even though only a few engineers will work directly for the nuclear power industry.

The civil engineer has a new set of tools in radioisotopes, and new problems created by these same radioisotopes. If he is to meet the challenge he must prepare himself accordingly with the fundamentals of modern physics, statistics and possibly electronics.

Rating Teaching Personnel for Advancement Purposes

By EUGENE H. BROCK

Associate Professor of Engineering Drawing, Agricultural and Mechanical College of Texas

Introduction

The business of rating professional personnel regardless of field has been proven, wherever tried, to be a most delicate procedure. The person or persons responsible for such a task must exercise a special kind of imagination which enables him or them to visualize the extent and character of work done by an individual during a work year. There is a certain amount of dealing with the unknown—of looking into the crystal ball. The "individualism" characteristic of the teaching profession particularly does not lend itself to close grading. The efficiency of college personnel is not so evident as that of personnel in industry, hence, performance of the individual is not based primarily on the efficiency with which he or she works. The validity and worth of the individual's work is not always discernible in the end product (graduate). Results cannot be tabulated day by day or even year by year. It appears, however, that the following points might be considered as evidence of good teaching qualifications and consequently may have considerable bearing on promotions, etc.

1. Mental ability and alertness of a high order
2. A high sense of social responsibility —rendering graduitous public service
3. Interest in the profession with a motive for service
4. A foundation of knowledge upon which a career can be built by experience (with a desire to learn and expand constantly)
5. Activity marked by individual responsibility
6. Self-expression implying a joy in one's work
7. Sharing advances in professional development

The successful management of labor and the study of human traits relative to employment environment is of prime importance and it appears logical from the many difficulties involved in evaluating evidence for fair ratings and promotions that perhaps the best approach would be from the use of an independent personnel department working in conjunction with the various administrative persons concerned. Many large organizations have found this approach to be both economical and practical.

Present salary advancements seem to be given unexpectedly—even to the receiver and though supposedly done in strictest confidence, the information is soon spread throughout the department concerned. This is a continuous source of irritation to other members of the department who perhaps feel that their performance deserves the same consideration. One "sore-head" can spread a tremendous amount of discontent in the college system. The point being attempted is that salary increments do not now follow any regular pattern in most institutions. Other criticism is more or less directed toward the college-wise system of salary adjustments. As an ex-

ample, School A is able to pay its members more than School B, and Department P in School A is paying its members more than Department Q. In many instances, certain departments seem to be able to secure pay and rank raises more readily than other departments. All of this leads to an indisputable source of trouble and discontent throughout the institution following such a pattern regardless of how well the administration keeps the facts from the staff. Personnel will discuss these matters when and wherever two or more get together.

The fact that colleges as a rule pay less than industry is well known and the individual entering the college profession is certainly aware of the differential. It does not appear that this circumstance has very much to do with the criticism of the average college advancement system. Colleges, as a rule, offer many advantages that industry cannot hope to offer and through proper channels these facts and advantages could be made felt throughout the staff. The whole pay and rank situation seems to stem from the lack of a progressive evaluation of what each individual staff member does and is capable of doing for the college and from the fact that too many persons are treated differently from other persons without good and apparent reasons. Salary increments are not to be likened to prizes at a drawing or party, but must be yearly and in all instances follow a set pattern unless good reasons have been advanced and are known by all concerned.

Objects of an Advancement Program, Rank and Monetary

Every individual employee in any organization is interested in the advancement program sponsored by that organization. Many prospective employees accept or refuse employment on the basis of such an advancement program and in many instances terminate their employment because of the lack of a solid program. The administration should be able to point with pride to the possibilities afforded an incoming employee and present employees under the institution's advancement schedule.

The advancement program should be divided into two phases; yearly salary increments and, secondly, advances in rank when the person has met the requisites for a particular rank. These requisites are based upon performance in the previous rank, experience and education. It is assumed that tenure will play an important position in the establishment of the various ranks, but it must be emphasized that tenure in itself does not qualify a person for a raise in rank.

Questions Relative to Rating Personnel and Establishing an Advancement Program

Questions and problems related to the establishment of an advancement program are listed below:

1. Does the party or parties responsible for advancement use a specific method for determining advancement on the various levels?
2. Is there a scale used whereby the individual might expect a percentage salary increment (depending upon monies allotted the institution from budgets) each fiscal year so long as their performance is satisfactory?
3. What does the administration consider as major factors in the advancement program? (These may be included in the next question.)
4. What weight or credit, if any, does each of the following items receive in the advancement program?
   a. Degrees
   b. Teaching experience
   c. Industrial experience (where applicable)
   d. Tenure in one's present job
   e. Professional registration or recognition
   f. Contribution of professional papers and books
   g. Research
   h. Recommendations by responsible and qualified persons.

There is no implication intended that it is possible to extend an exact value to any of the above listed items, but it is a proven fact that under normal circumstances a method of weighing groups of such characteristics is possible and feasible. It is highly essential that the staff know that administration at least considers such qualities as requisites for regular promotion and that all or which parts are considered in the annual review of personnel.

Reasons for Items Suggested in Advancement Program

a, b, c. *Degrees, teaching experience and industrial experience.* It is a well known fact that a statement of degrees earned, plus years of teaching experience plus years of industrial experience is not an infallible nor an accurate measure of the quality of teaching one does or is capable of doing. There will always be individual exceptions to these measures of teaching ability. There are excellent teachers who do not hold degrees of any sort and likewise, there are those teachers who hold Ph.D.'s from our best institutions who do not possess the qualities required for good teaching. Yet it must be recognized that by and large training as evidenced by advanced degrees and experience in both industry and the teaching profession are requisites for a well-rounded teaching experience. Credit must be given for having such requisites.

d. *Tenure* does not necessarily qualify one for an advanced rank nor does it justify an increment in salary, but every organization must promote tenure if a sound basic organization is maintained. There should be an approximate time limit that a person would normally remain in a given rank. This will certainly not hold true in all instances, but primarily refers to those persons who have done a good job consistently year after year. It seems sensible to promote an individual out of the instructor class at the end of five years. If he is not worthy of such a promotion at the end of that period, he should be released from his duties; continued service might be harmful to his students or the college. An associate professorship might be granted at the end of ten years of good service and the full professorship should be given between the fifteenth and seventeenth years. It is understood that there will be exceptions to any specific objective, but such an objective would bring about better relationships among faculty members.

e. *Professional registration or recognition* must be encouraged with more than just a "pat on the back." Many institutions have set up professional registration as a requisite for new employees, particularly in the engineering college. It seems feasible to require some professional recognition as a requisite for all personnel entering the teaching profession, and if possible, pressure should be applied to existing personnel to improve their status.

f. *Contribution of professional papers* perhaps should be included in the previous paragraph. Certainly some credit should be given to those who are willing to devote time and effort to the writing of books and other publications. Such work strengthens the originator and indirectly promotes the welfare of the college.

g. *Research* is an intangible factor and must be weighed very carefully in the over-all advancement program. Many persons do not possess the qualifications for pursuing research yet these persons may be excellent teachers. However, many teachers do an excellent job in research and certainly should be encouraged to pursue this qualification. Most teachers would benefit immeasurably from part-time work in research. This would be particularly true where the person is unable to afford time in industry. The teaching experience would be enhanced by actual experience and know-how in a direct application of knowledge in their particular or related fields. Too, the students would benefit from the freshening

effect of other interests than the general course requirements. Most teachers who are doing research work along with their teaching find that there is ample opportunity to bring some of the experiences in research to the classroom. Some weight should be given in the advancement review to those who possess abilities in the two professions, but not stressed to the extent that good teachers become prone to forget their teaching performance to seek the bounties of research.

h. *Recommendations by qualified persons* will be discussed in later paragraphs as a part of the scale ratings. It is sufficient to state here that all recommendations (including student ratings) should be considered, but as a guide only—not as the final measuring stick.

Specific Suggestions for Rating Personnel

It seems both possible and feasible, contrary to the belief of many well-informed people, to evaluate the performance of college personnel. Present evaluation is based on many minor and sometimes not correlated items such that the real reasons for salary increments and rank raises are often overlooked. It is also true that many institutions do not have a bona-fide advancement program and a majority of the institution's personnel flounder around attempting to hit upon a quick way or means of attracting sufficient attention to "rate" a promotion. In some instances this effort is carried on to the extent that the real objectives of teaching are forgotten. On-the-job performance is the only legitimate means of obtaining a promotion and all evaluation should be based on this philosophy. Such evaluations should fall into three natural categories:

1. Normal or average performance based on assigned duties
2. Above average performance based on assigned duties (it is assumed that such persons carry on an active program above assignment)
3. Below normal performance.

The phrase, "natural categories," was used because there will always be a natural selection of those three levels in the various departments and in some instances on an over-all college level. Those persons gifted with outstanding characteristics or who are willing to do extra work will enter into their job in such a manner as to be indispensable or at least be noted by all concerned. Below average performance will likewise be noted just as strongly.

Performance is the key to a workable advancement program. And those persons responsible for advancement must adopt a means for differentiating the various levels of performance. It is the contention of this paper that the three levels of performance listed above are sufficient to do the job.

The Weighted Scale—Performance Method of Determining Advances in Salary and Rank

It is believed that an established practice of using the weighted scale similar to that used in industry along with performance evaluation will eliminate many difficulties which have been experienced with existing systems and in so doing will promote tenure of the staff. Figure 1 illustrates a scale which lends itself to such a system as recommended in this paper.

It will be noted that three curves are used; one for each of the standard degrees. Salary is based largely upon the number of years of acceptable experience. Each of the curves used has a base salary which would be considered as the minimum salary to be paid for entrance into the institution's staff. Normal or average performance would constitute reason for following the curves. Should legislative action be of such a nature as to prevent following the curves as shown (budgetwise), percentage raises, based upon monies in the budget and percentages relative to the scaled curves would be granted. This would assure all personnel the right of obtaining salary increments

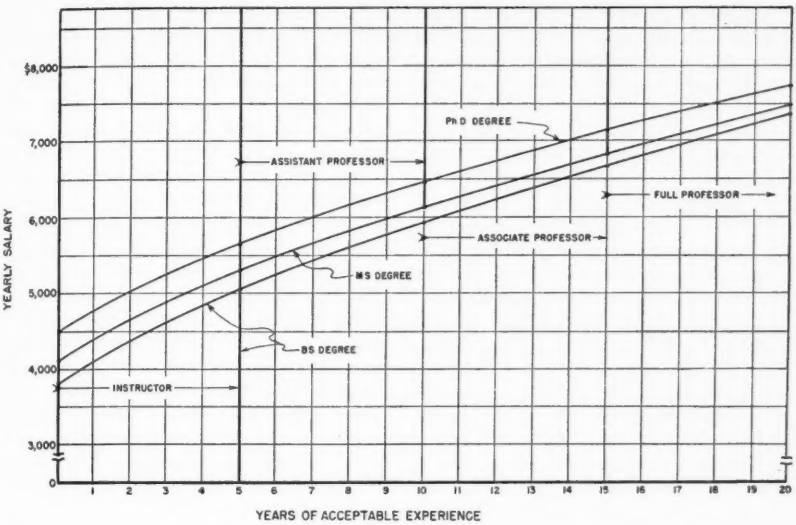

FIG. 1.

on the level with other fellow workers regardless of department.

Initial Hiring Factors to be Considered

The institution should adopt a system of hiring which would include the following concepts:

1. Personality
2. Scholastic record (to indicate promises of development in a specific field. To be used with other factors)
3. Experience
   a. Industry
   b. Teaching
   c. Other

   (The number of acceptable years would indicate partially the base starting salary)
4. Evidence of ability to cooperate with others
5. Indicated promises of future development
6. Interviewer's evaluation
   a. Departmental level
      (1) Staff
      (2) Department head
   b. Dean or personnel department
7. Unusual contributions in field of assignment
8. Character of experience (partially evaluated in item 3)
9. Recommendations by qualified persons

Length of experience must be weighed by factors representing true values of experience to the job applied for. As an example, a year of applied research in industry might be considered equal to two years of teaching experience in some positions. One year of work in construction might be equal to 1½ years of teaching experience to a position in the Civil Engineering Department and on the other hand might be practically worthless in other positions. Regardless of how difficult this job of evaluating may seem, many fine organizations have used it successfully for many years.

Specific Example of Initial Hire

Person applying for the position is a graduate of an acceptable institution. He has a Master's Degree in the field of application. Grades on his transcript were acceptable and recommendations from responsible persons above average. A telephone contact has been made with

the person applying for the position and he has indicated that he is still interested in accepting employment if conditions are mutually agreeable. The head of the department involved requests that the applicant (where possible) visit the college —at the *expense* of the college. The applicant is given an opportunity to visit the department involved and normally several members of the department are given time off to spend with the applicant. The head of the department should not discuss policies of the department or any other matters of college business until the other members of the department feel the applicant will find himself an agreeable place in the organization. After the department head has had an opportunity to thoroughly discuss the applicant with those persons responsible for the interview, he will make his own personal contact with the applicant. The head of the department will then send a record of the interview together with the recommendations of the department. The final interview of the applicant is with the dean of the school involved. If an offer is made, the applicant should be made aware of how his particular level of employment was reached. The advancement program should be explained and other details relative to the objectives of the program fully explained. Such an introduction to the college will assist the prospective employee in his integration into the college environment.

The applicant illustrated was offered $5150.00 based upon four years of acceptable usable experience (other qualifications being acceptable).

Rating an In-service Employee

The principal source of information for rating an in-service person is the department in which the person works. This statement does not imply that the head of the department should be the sole judge of performance and qualifications of each member of his department. As a matter of fact, this does not seem to always be the most practical answer to the grading problem. In many instances other departmental personnel should be asked to give additional information (a maximum of two persons other than the department head). Such information must be treated confidentially and in no cases dwell on personal items. Circumstances relative to information should be obtained (friendship, competitive feeling in same field, grudges, etc.). Should a person be classified in a substandard rating, the head of the department should provide sufficient written evidence to back the classification and provide the personnel department or Dean with reasons for retaining such a person on the staff. Such a rating would constitute reasons for administrative personnel to have an extensive review of circumstances relative to the employment of the person—considering all elements relative to environment and departmental relationships.

Average performance ratings should follow a set pattern through the scale. From Fig. 1 it would be possible to determine salaries of employees A and B with four and sixteen years of accepted experience. Employee A (B.S. Degree) would expect to get a raise of $22.50 per month, while employee B (B.S. Degree) would expect to get a $15.00 per month raise. The curves illustrated tend to level as the number of years of acceptable experience increases.

Above average performance ratings would be subject to a review by the Dean of the School involved and perhaps by the Dean of the College. An additional salary increment above the scale might be granted and in exceptional cases, a raise in rank might be justifiable. It is difficult to substantiate a definition of what constitutes a rank raise, but certainly in any case every rank should have considerable meaning for the participant. Tenure should mean a gradual raise in salary and over a period of time a raise in rank if performance is satisfactory.

Conclusions

In order to build a faculty strong in all phases of activity and high in morale,

it will be necessary to adopt an aggressive and progressive advancement program for all staff members. This statement does not intend to imply that each employee will receive an increment in salary each year nor does it imply that each employee would expect a raise in rank each specified period, but does mean that each employee will be able to justify his position on the advancement curve and can expect proper treatment and explanations for below-average performance and for above-average performance.

It is believed that the initial hiring of an employee should be done with the knowledge that the applicant has the necessary qualifications to follow the advancement program. Necessary steps should be taken to assure the continued performance of that individual. The following seems feasible:

1. A suitable orientation program during the first year of employment, departmental and college-wise.
2. In-service teaching training—colloquium programs
3. Periodic interviews by department heads and other administrative personnel. (Performance review and general consultation)
4. Recognition of advancement
   a. Degrees
   b. Professional registration
   c. Professional recognition
5. Other constructive criticism, etc. The use of the student rating system is a part of this item. This person believes that such a rating can be made to work properly and be most helpful to every employee)

An Integrated Approach to Basic Mathematics

By W. R. VAN VOORHIS

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The importance of basic mathematics in engineering curricula is recognized by the Engineers' Council for Professional Development. In fact, there is almost universal agreement among members of the engineering profession that basic mathematics, along with the physical sciences, forms the foundation of engineering training. In discussing factors of major significance in curriculum design, the Committee on Adequacy and Standards of Engineering Education emphasized the sustaining value of mathematics in the curriculum.[1] The report pointed out that the "greatest potential for future development in science and technology is to be found in mathematics. An engineer with a good knowledge of mathematics is in a position to read with understanding and profit in physics and chemistry. Likewise, as his interest and need may expand, he may read further in the applied sciences, such as mechanics, elastic stability, advanced thermodynamics or fluid mechanics." In continuing the discussion of new applications of science to engineering situations, the report pointed out that "mathematics not only becomes the support of the group of courses that will obsolesce least," but that it also "becomes the means of further technical growth as befits the graduate's interest and need." It is apparent, therefore, that course content, arrangement of topics, and methods of presentation are all subjects of great concern to those of us who are responsible for the training of engineers.

[1] S. C. Hollister, and others: "Report of Committee on Adequacy and Standards of Engineering Education," THE JOURNAL OF ENGINEERING EDUCATION, Vol. 42, p. 252.

The Conventional Offering of Separate Courses

As is well known, the material ordinarily classified as "basic mathematics" has been taught in separate courses with little emphasis upon connecting the concepts developed in the various topics. The conventional method of approach has usually taken the form of fairly standardized courses described as college algebra, trigonometry, analytic geometry, and so on. Although the scope of material that can be included under the heading "basic mathematics" is arbitrary, there seems to be some justification for looking upon the three courses named as basic in that much of the groundwork for more advanced study is developed in these courses. In fact, most course outlines seem to emphasize that development of skills and preparation for later courses are their fundamental objectives. Let us, therefore, confine our attention to those topics ordinarily treated in college algebra, trigonometry, and analytic geometry, together with such applications as may be found in the fields of mechanics, physics, and so forth, as, for example, moments of force, uniform motion, and other simple applications. It is fairly safe to say that there are many teachers of mathematics, and certainly a great number of members of enginering faculties, who feel that the formal presentation of these subjects should be critically examined, not only with the view of obtaining greater mathematical competence of their students, but also to develop appreciation of

the interrelationship of mathematics and other phases of their training.

Trend Toward Integration of Topics

The formal presentation of the topics of basic mathematics in separate courses is so easy that the advantages of some sort of integrated approach are often overlooked. In a paper presented before the Indiana Section of the Mathematical Association of America, Professor M. E. Shanks of Purdue University made some definite remarks with respect to this point.[2] He pointed out that the "classical algebra, trigonometry, and analytic geometry sequence has had remarkable survival value." He goes on to say that "when one considers that it has been in existence for several generations without essential change (except for some dilution in content) it is hard to imagine how such a fossilized entity could so long endure." Professor Shanks contends that "we are surely ripe for a change."

Most colleges have, for many years, followed a line of least resistance, presenting the basic courses in a manner so familiar to all. Typical examples of the formal presentation show quite clearly the lack of any blending of ideas, although in many cases it is actually very difficult to prevent the bringing together of certain topics. For example, extensive drill is given in solving quadratic equations in algebra, with the unknown usually restricted to the letter x, but consideration of the same equation if the variable happens to be a trigonometric function is deferred until the course in trigonometry. Very seldom are the symbols of calculus, or those employed in electricity and other applications included in lists of drill problems. Yet it is certainly possible that even in the limited sense using the symbolism of other courses can prove to be beneficial to the student in his later applications. As another example of the questionable advantage of a formalized treatment, consider the study of the straight line. A student receives much drill in handling linear equations in algebra, but is denied the pleasure of graphing the linear function until he has reached the study of the straight line in analytic geometry. Only in rare instances does he fit a straight line to data, and this task is usually looked upon as an extra topic that can be taken up at the end of the course, if time permits.

Although the formal method of presenting basic mathematics has had a firm grasp upon our colleges for many years, increasing efforts are being made today to blend the topics in some manner. For evidence of this trend, we need only to examine the course descriptions in the college catalogs. In making a study of the catalogs of 25 leading engineering colleges, the following results were obtained:

	1941	*1954*
Integrated	5	16
Conventional	20	9

Of these 25 colleges, 5 offered in 1941 some type of integrated program, whereas 20 of them were offering the conventional courses. The integration of topics at that time consisted chiefly of offering in one course a few topics from one or two of the other courses. For example, trigonometric equations might be taken up in the algebra course; or perhaps combinations and permutations might be given in the analytic geometry course. In 1954, 16 of these same 25 colleges are offering courses that combine, in some fashion, topics from the three conventional courses, and 9 of them are still offering the separate courses. In reading the course descriptions, one obtains the impression that a greater attempt has been made to bring together topics in some planned fashion.

The change in the course content arrangement of these colleges is evidence that there is a tendency towards the adoption of some type of integrated or unified

[2] M. E. Shanks: "Mathematics for Engineers," THE JOURNAL OF ENGINEERING EDUCATION, Vol. 41, pp. 308–309.

presentation of the topics of basic mathematics. In a few instances, topics from analytic geometry have been combined with the study of calculus, but these are those in which algebra and trigonometry are not a part of the curriculum. It is interesting to note that not one of the 5 colleges offering a type of integrated program in 1941 has returned to the conventional approach at the end of the thirteen years.

Need for Planned Integration

The trend towards some program of integrated basic mathematics is the result, no doubt, of observations of ineffectiveness of separate course offerings. For many years my colleagues and I have been concerned over the lack of simple skills possessed by students in later mathematics courses, although they had been given intensive drill in the basic courses. The inability to make analyses of problems and to apply simple procedures already learned must be accounted for in some manner. We began to look around for an explanation. We could have reasoned that the explanation was simply lack of background on the part of the entering students, and would have certainly found many in agreement. But this would not have been a realistic solution. We had the students and it was up to us to do our part in rounding out their engineering program. We were certainly safe on one basic assumption—our students were of two groups—*above-average,* and *below-average.* Could we decide upon a set of assumptions upon which a program of integrated basic mathematics could be built? From the students themselves we learned one interesting feature which could possibly account for some of the ineffectiveness of the conventional courses. Below-average students admitted that the formal courses, containing, as they do, a repetition of much of the high school work, failed to arouse their interest in mathematics because this same kind of presentation had done much to dampen their enthusiasm in high school. The above-average students admitted that formal courses encouraged them to "take it easy" upon beginning their college career. Here they found material already rather easy and familiar to them, and so they could spend their time on other subjects. If these students reactions, then, were correct, none of our students, generally speaking, were beginning their careers with much inspiration as far as mathematics was concerned.

From instructors in other departments came the pleas for greater emphasis upon applications. Many of them felt that more use could be made of mathematics in their courses if there was a greater correlation between the time the material was taken up in mathematics and the time at which related topics were being discussed in applied courses. At first we tried to incorporate the study of calculus with the topics of analytic geometry and other basic courses, but we were not entirely satisfied with the results, because of the lack of basic skills in later courses. We decided to keep calculus in the sophomore year, treating it as an application, just as we did mechanics, physics, and other courses in the curriculum. Certain topics, however, such as the limit of a sequence, convergence and divergence, the writing of general terms of series, and the comparison test for convergence could be blended in with topics of the basic courses. Eventually, our aims became clear. We wished to establish a program that would (1) increase motivation and interest, (2) emphasize applications in other courses, (3) correlate the time of presentation as far as possible with related topics in other courses, and (4) retain at the same time the desirable features of rigor and analytical thinking that could result from the thoroughness of conventional courses.

Assumptions Underlying a Program of Blending

After much preliminary investigation we finally decided upon the following

assumptions for our program in basic mathematics:

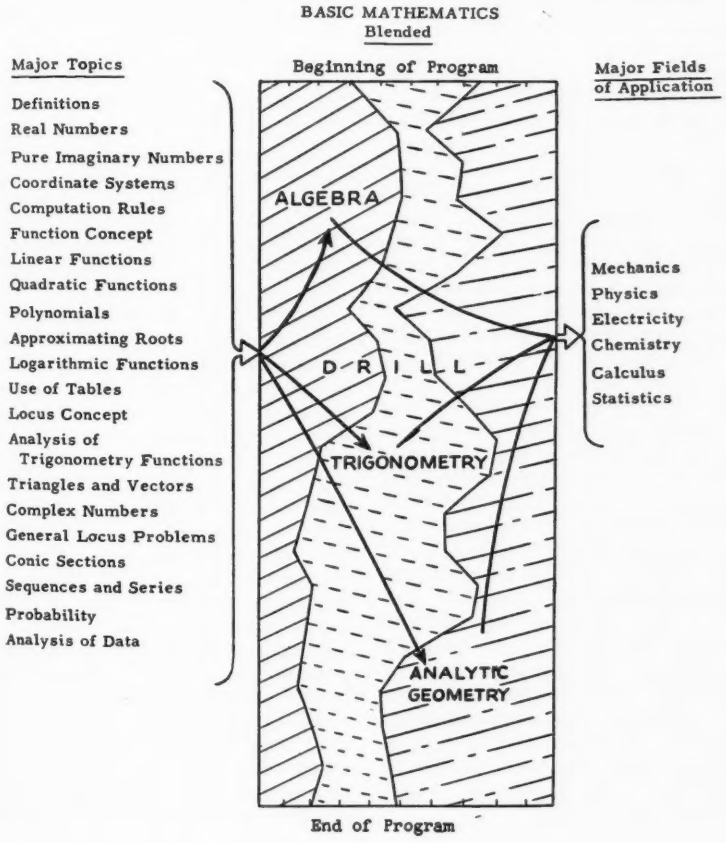
(1) Basic mathematics should begin with and emphasize the function concept.

(2) Formal drill should be interspersed throughout the program in connection with other topics which, for the student at least, are more interesting.

(3) Essential features of all conventional topics (and we found none that could be entirely left out) should be *blended* so as to give the student an appreciation of their interrelationships.

(4) The presentation should be of such a nature as to encourage the student to study the text material, gaining his own information preliminary to the solving of problems and without depending upon lectures by the instructor.

With these assumptions in mind, the course material was written and revised several times. As indicated in the accompanying chart the subjects of algebra, trigonometry, and analytic geometry appear in a vertical arrangement, instead of horizontally, and drill cuts across all topics. The width of each of the three major areas at the position of a major topic on the time scale indicates the approximate percentage of "emphasis"



devoted to a given phase in each of the time "areas."

The Process of Blending Topics

The material was designed to be ample for three quarters of work, or a total of 150 hours. As the chart indicates the emphasis is upon algebraic phases during the first quarter, trigonometric phases during the second quarter, and analytic geometry during the third quarter. In each quarter, however, topics are treated so as to cut across all three fields with illustrations and applications that can be used at the level of development. As an illustration of this blending, let us consider the treatment of the straight line.

Because of an early introduction of the definitions of the trigonometric functions, angle measure, and coordinate systems, a rather complete study of the straight line is possible in the first quarter. This topic furnishes the beginning of the locus concept, and serves as motivation for an interest in the analysis of data. Simple applications are taken from problems involving forces, electrical circuits, uniform motion, and so forth. At no time is a topic considered to be finished; but repeated usage of ideas learned are made throughout the three quarters, and ideas are expanded upon after further material has been introduced. For example, the equation of a line through two points is tied in with fitting of data by the method of average points; then "least squares" is employed after cross reference to the maximum and minimum points of the quadratic function and the study of probability.

The parabola provides another illustration of correlation of material. This conic is introduced quite naturally in connection with the study of the quadratic function. Later, in connection with more general locus problems, a more thorough treatment is given after translation and rotation have been studied. Applications are made to problems in highway engineering, bridge construction, reflector design, and so forth.

Advantages of a Blended Approach

The question naturally arises as to the advantages and effectiveness of the blended or integrated approach. In the first place, motivation and arousal of student interest in the study of mathematics are greatly increased. When beginning students are presented with a formal course in college algebra, two types of reaction are quite apparent; The above-average student recalls that the material is quite similar to that studied in high school, and consequently is inclined to "take it easy," feeling that he is already familiar with the material, and can spend his time on other subjects. He gains no inspiration to study mathematics. The below-average student is discouraged. Here he is confronted with the same type of presentation that he probably found somewhat distasteful in high school. The result, for a great many students, is failure to begin the study of engineering with the proper frame of mind. The introduction of interesting applications of an enginering flavor made possible by the blending of topics has the effect of catching and holding the interest of all students.

Probably, one of the aspects of the problem that has been instrumental in the survival of the conventional approach has been that of drill. When one begins the blended type of presentation, introduces a topic, leaves it temporarily for another one, returns to it again for a while, brings in outside applications and continues in this manner, he is likely to feel that the advantages of necessary drill have been overlooked. This, however, is not the case. By interspersing drill throughout the program, the effects are more lasting; and as a result of the continuity of instruction, more skill in manipulation is actually retained in later courses than results when the drill is concentrated early in the program. It is much more effective, for example, to drill in factoring when this operation arises in connection with solving the quadratic equation, when finding real zeros of a

polynomial, etc., rather than to give it all in one dose, and hope that the results of the injection will be permanent.

Perhaps, one of the chief advantages of the blended approach is a byproduct of the manner of presentation of material made possible by the cutting across of segments of the basic courses. The material can be written in a manner that the student can follow the unfolding of concepts, and at the same time understand the derivations and illustrations. To a larger extent he is thrown on his own, for he must do a certain amount of cross-reference reading while studying the text preliminary to solving problems. This gives practice in reading mathematical material, and enables him to experience the joy of success as a result of his own efforts, without depending upon lectures by the instructor. The instructor, in turn, has more time available for diagnosis of difficulties and special problems.

The training in analysis afforded by the blended and unified presentation of basic mathematics, the stimulation of student effort, the correlation of mathematics with other subjects, and the improved performance in mathematics in subsequent courses, are strong arguments for the adoption of this type of program by colleges of engineering.

Dues Amendment

The amendment to By-Law Four relating to dues of individual members of the Society, was passed by a majority of over 76% of the 2,283 members who cast votes. This provides for a nominal increase in dues. The dues for next year, according to the amendment, will be $8.00 for members over 36 years of age and $6.00 for members under 36 years of age as of July 1, 1954.

The Tellers Committee consisted of Dean Frederick Tresize, University of Illinois, Navy Pier; Dean R. G. Owens, Illinois Institute of Technology; and Professor E. F. Obert, Northwestern University.

Discussion of Preliminary Report of A.S.E.E. Committee on Evaluation of Engineering Education *

By ROY M. GREEN

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A More Logical Suggestion for Improving Engineering Education

The report contains much material of great significance. A major weakness rests, however, in its many contradictions and vacillation from one point of view to another. This weakness, in my opinion, results from not arranging facts and opinions in the order of their importance in arriving at recommendations. What I believe is such an arrangement is given in the following pages.

1. Our duty as engineering educators is to develop *MEN*. Our educational programs should be designed to assure the *maximum rate of progress of every individual, student and graduate, as he develops in the engineering profession.* This has been our goal in the past and it would be wise to keep reiterating it in our speech, writing and thinking.

The report however departs from this philosophy on page 1, paragraph 2. *"It is the responsibility of engineering education to provide that kind of educational preparation which will assure maximum rate of progress of the engineering profession."* Again on page 25, paragraph marked 6, *"This concept places service toward advancement of the engineering profession first on the list of objectives of engineering education."*

Placing the development of persons below that of scientific findings for a profession is a dangerous backward movement in a free society. In the end it will wreck both the society and the profession.

2. Engineering College graduates play a vital role in the protection of our nation and the preservation of our standards of living. Both *quality* and *numbers* superior to our present supply are required. (Page 13, paragraph 7) "Higher selectivity would decrease the number of applicants *at the very time when national survival calls for the elimination of the present shortage of engineers.*"

This is an accepted truth by practically everyone, yet on page 24 we find this: "1. In a limited number of institutions it would be possible to choose between the professional-general or the professional-scientific approach to engineering education and to *select the student body* to fit the chosen curriculum pattern."

This can not be a serious recommendation if the statement on page 13 is correct, and I believe it is. In 1946 a few engineering educators urged all college deans to quota the number of veterans by rejection, so as to *save* the profession from a disastrous oversupply—yet today our "national survival calls for the elimination of the present shortage of engineers." As citizens of the United States, what right have we to prejudge

* Dated October 10, 1953.

all our young men by saying you go this way—to engineering—and you, over there, go another way to a place between engineering and some other activity. (Professional-general service is defined as between engineering and many other activities on page 18, last paragraph.)

3. The educational development of a constructive professional man does not end when he quits attending a college or university, regardless of 4, 6, 8 or 10 years attendance. (See page 7) "It is difficult to over-emphasize the necessity of learning how to study and of continuing study throughout a whole professional career." (Also see page 8, paragraph 3 and page 18, paragraph 3.)

This is a truth which no one will flatly deny, yet in the report, we have suggestions indicating that unless development is accomplished in college, it can never be achieved. (Page 8, paragraph 3) "The technical goal of engineering education (I assume the college program) is preparation for performance of the functions of analysis and design or of the functions of construction, production or operation with *full knowledge* of analysis and design of the structure, machine or process involved."

(Page 15, paragraph 6) Speaking of the necessity for more than four years of development, the report continues "For many, this increased training will have to come from graduate study at the highest professional level. For others, industrial experience or self-study may suffice." Does this mean if one takes graduate work he needs no self-study afterwards? Is college the end? If it is, I believe it is also the end of the engineering profession. As educators, have we lost our way in self-admiration? (Also see page 12, paragraph 5 on Humanistic-Social studies.)

4. No system of pre-judging of students is perfect. The earlier judging is attempted, the more imperfect its results. Any educator who has followed predictive-testing has observel classical examples of men who finally proved themsevles to be excellent students who were, by prediction, failures or near failures. (This is acknowledged by reference page 13, paragraph 7, given above.)

Under the recommendations, however, given in the report, the men who are to be the leaders in the profession 25 years hence will be selected at or near the beginning of their undergraduate career.

5. Practically all educators will endorse every detail of that part of the report entitled "Requirements for Admission" on page 17. Note that this firm and inclusive recommendation permits even a marginal or rejected student by predictive methods to have a fair chance to prove his eligibility for a constructive education.

Basic Facts

We therefore have five basic facts which are almost universally accepted, namely:

(1) Our primary duty as educators is to develop *men* and not to discover new scientific facts or accumulate new scientific data.

(2) Our Nation sorely needs more men with higher educational development in engineering in all its aspects.

(3) Education must continue throughout the life span of a man.

(4) Systems of pre-judging are not perfect and the earlier judging is attempted, the more errors are made.

(5) We have a reasonably acceptable guide for admission. In other words, we have reasonable agreement upon when the primary responsibilities for the education of engineers is *ours.*

With this set of facts, why is it not sensible to define the ultimate goal of a fully developed engineer, then determine what can best be done in the brief academic interlude when the student is in college? (Such an attempt was made at the University of Nebraska.)*

Since we seem to be agreed upon the

* Listed at the end of this article.

requirements for admission to an engineering college, we are also agreed that the starting point is the same for all—the highly gifted learner and the less brilliant student. We should be able to reach reasonable agreement concerning minimum coverage in the basic sciences and mathematics. All students should be required to reach these requirements but this does not prevent the unusual students (say from 5% to 25%, depending upon the class) from going much further in these basic areas.

This superior group can be fairly well identified by the time they have worked with the faculty for 2, 2½ or 3 years. Such students do not need many illustrations of the techniques of applying basic science to engineering problems and could, therefore, lay a broader and firmer foundation in the basic areas. This would avoid the inevitable losses of manpower resulting from an earlier screening and would make the relative capacity of the potential engineering scientist much greater and would not lose the effect of their inspiration on the rest of the student body.

Those who needed the repetitions of application courses would go into the professional-technological fields. This is a field the report does not envision but is an important one to contemplate. The report describes "general professional engineering service" (page 18, last paragraph) as being *between* engineering and a great variety of other things. In other words, professional-general is not engineering at all according to the description. Hence, the recommendations of the report imply splitting engineering wide open. We do not need division, we need consolidation. Engineering involves a wide expanse of human effort covering the whole spectrum from scientific to technological in all its aspects. Our selection should not be between the alternatives of scientific and general but should rather include *both* scientific and technological. Both "bifurcation" and "starring of curricula" are definitely backward movements and can only cause confusion, distrust and dis-unity in our society. We must strengthen our educational programs not tear apart the structures of engineering education in the United States.

A Suggested Statement of Policy for Engineering Education College of Engineering and Architecture University of Nebraska

Complete competence in engineering would include the following:

a. An understanding of mathematics and the physical sciences; a knowledge of the characteristics of materials; and familiarity with engineering methods;—resulting in ability to analyze, design, construct, operate or manage engineering works or projects.

b. An understanding of economics and finance;—resulting in ability to appraise the economic aspects of engineering works.

c. An understanding of the fundamentals of human conduct and the principles of management;—resulting in ability to organize the efforts of individuals and groups in an effective prosecution of engineering works.

d. A facility in forms of expression;—resulting in ability to discourse in written and oral form in the language of the arts as well as in the symbolic language of science.

e. An understanding of the evolution of the social organizations in which we live;—resulting in ability to appraise the influence of science and engineering on their development.

f. Familiarity with the great documents of arts, morals and religion;—resulting in an appreciation of the dignity and worth of human personality, the principle of social justice, and the principle of sharing for professional and social gain.

g. An appreciation of the obligations of citizenship;—resulting in a readiness to give intelligent service in the improvement of home, church, school and state.

h. An enthusiasm for learning;—resulting in a burning desire to continue the

study of engineering and to search for the values in other fields of thought.

Such competence is the goal of a lifetime and not that of the academic interlude. The academic education in the purely technical field of engineering does not, and never did presume to equip the student with the requisite knowledge, or technique of practuce which, per se, allow him to function as a professional engineer. The character of the technical courses in engineering curricula should be such that the student's time is utilized in attaining two major objectives. First, that he gain the fundamentals upon which engineering is built, and second that he catch the spirit of engineering to the degree that he will continue the studies which lead to ultimate professional competence.

In the academic span of the total education of the engineer only a beginning is made in the field of engineering practice. Likewise, only a beginning should be attempted in the broad field of the humanities, relying in both cases upon the developed interest to carry the student toward his ultimate objective of professional competence.

Regardless of the number of credit hours required to earn the degree, each course to be taken by the student should be justified by the following reasons:

1. It serves as a positive aid in the ultimate achievement of at least one of the objectives (a to h).

2. It is definitely a part of the total education which cannot be achieved as well after graduation without a great sacrifice of time.

Axioms of Curriculum Change

By HERBERT A. SAWYER, JR.

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Consideration of engineering curriculum changes prevents stag ation, adds to our perspective, and, most important, may lead to real improvements in present curricula. However, too often such consideration is confusing and sterile of production of real improvements—all because of neglect of one or more of the following "axioms of curriculum change," compiled from the writings, correspondence, and conversations of many colleagues, who deserve more credit than the space available allows.

1. *Additions must be matched by deletions.* Cries for more communications, humanities, basic sciences, business, or creative design are meaningless unless the equal quantities of course material which must be dropped to provide room are specified. Present four-year curricula are now crowded to the limit, and the division of opinion on the five-year curriculum eliminates it as an immediate possibility. The question is not what is desirable, but which is *most* desirable.

2. *Increasing the exercise of student initiative is equivalent to adding course material.* If course progress is by the trial-and-error of student initiative, the rate of imparting scientific discipline is reduced 50 to 80%, thus increasing time requirements two to five times. The teaching load may be increased even more —increased individual attention is required to coordinate the wide variation in student progress and to correct false concepts and bad habits arising in individual students. Furthermore, only the cream of the class will exercise initiative, the rest following. Yet stifling of initiative would be disastrous. The solution of this problem, the most vexing in all of teaching, involves a nice balance between the advantages of student initiative and the economics of curriculum time and teaching resources, remembering that much initiative development can be deferred to the impelling practical situations of postgraduate years.

3. *Improvement of teaching efficiency is an insignificant factor.* We must strive for such improvement (to even hold our own), but it cannot serve as a basis for expansion of curriculum material. Teaching efficiency may have improved 10% in the 2400 years since Socrates, but this does not mean it will improve 10% in the next five years. Engineering teachers will still be humanly imperfect, and there are not many short cuts, discovered or undiscovered, in teaching students how to think.

4. *Overlapping of course content has some advantages.* Repetition is the key to thorough learning. Also, some overlap is necessary to show course interrelationships. Overlap at inconsequential points is obviously wasteful.

5. *Creation is an art, not a science.* Creativity and basic science cannot be increased simultaneously in the technical part of a curriculum. Creation must be discouraged when the child learns his multiplication tables, when the medical student is learning anatomy, when the law student is learning Roman law, and when the engineering student is learning to draw free bodies. Anyone, including the child playing with blocks, can be creative, but creativeness, to be worth any-

thing, must be based on discipline. The effective engineer has learned to limit his creativeness to the narrow paths useful to men and based on scientific and socio-economic principles. Only after these principles are learned can the engineer begin to learn and practice the art of engineering creation—the art which distinguishes him from the scientist.

6. *The four undergraduate years merely initiate professional training.* For *all* students, at least four postgraduate years of industrial "internship" are an integral part of professional training, and any curriculum study must consider these years. Because the body of basic principles and theory which the engineer must master is growing, more and more of the art of creative engineering must be learned after graduation and in this internship. Incidentally, changes in undergraduate curricula must involve careful weighing of industrial demands, even at the time of a "sellers' market" for engineering graduates.

For *exceptional* students, graduate work is also an integral part of professional training, and curriculum studies for such students must consider these years. Graduate work, presently so variable in quality and quantity, is by far the most fertile field for evaluation and change. Here the gifted student is short-changed, if anywhere. Probably the exchange of ideas which graduate accreditation would stimulate would alone justify it. Of course, more diversity should be allowed in accreditation of graduate curricula than in undergraduate curricula.

7. *"Bifurcation" is on the horizon.* If the ratio of engineers to total population continues to increase, the broadened base of engineering education will eventually force our acceptance of undergraduate segregation of gifted students preparing for graduate work, just as the adoption of universal high school education has led to our acceptance of segregation of college-prep students in high schools.

8. *Extraneous activities are not good measures of curriculum teaching quality.* A teacher who is distinguished in research or graduate instruction, two valid functions of a university, is, however, not necessarily distinguished in performing its third function, undergraduate instruction. Nor is the extent of consulting work or professional-society activity a good measure of excellence of undergraduate instruction. Nor is evaluation by immature students. A reliable measure of instructional quality is much needed.

In summary, curricular revision never involves a simple choice of black or white. When all factors are recognized the choice is usually between closely matched alternatives with the time factor often governing.

Motivation in Engineering Education

By EDWARD M. BENNETT

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Consideration of the basic patterns of motives that urge young men into engineering can often serve as the first and best basis for increasing the over-all efficiency of the engineering educative process. When the conditions of education are such as to thwart, inhibit, and otherwise threaten or frustrate the needs of the student, the educative process becomes inefficient to the point of obsolescence or uselessness. When, however, the needs of men are recognized and taken into account, in planning an educative effort which eventually leads to gratification, students can be expected to exert all necessary efforts. For a student, as for anyone else, where a goal is not attractive, effort toward the goal is folly.

There are a set of pressures—cultural, social, and individual—that direct individuals toward an engineering career. Although each individual will evolve as a unique pattern of these pressures, consistencies, general tendencies, and trends can be noted. The needs of persons who seek an engineering education are but slightly different from those who strive for competence, acceptance, and general gratification through other fields of endeavor.

The cultural core of the concept of engineering hinges upon a basic belief: an individual human being can master the rules and processes of nature, and then turn them to his own purposes. Accepting such a cultural value, the individual's life is one of achievement, and not ascription. What success one gains is gained by skillful effort, individual personal exertion, and directed activity. In other words, science and technology stand upon the basic premise that one's rewards, successes, pleasures, and gratifications come from one's own fundamental mastery over the plans of natural order. Engineering is not for passive people, and so it is that one would expect the need for personal achievement, competence, and self-esteem to be high among engineering students.

The Engineering Student

The teen-ages are unquestionably a period of reorganization for the average present-day adolescent. Childhood modes are no longer adequate. Dependency and conformity to parental standards no longer elicit much reward and respect. The adolescent boy must show his own skill, make a name for himself among his peers, and strive for a feeling of self-respect based on how he is respected by other adolescents. The prize skills of adolescence at the present time, the skills most worth having in the eyes of other teen-agers, male and female, are (1) physical prowess and athletic talent, and (2) mechanical know-how and scientific-engineering "tinkering" ability. To be male, to be popular, to be wanted, one must show off one's "self" by acts of symbolic mastery; mastery over people in physical activity and mastery over things by technical advantage. The hot-rod is more than an automobile; it is a daring stallion for demonstrating combat and courage on the road. It is a powerful representative of "me," the masterful, the cam-conscious, cylinder-oriented, carburator king. It is through many pathways that the adolescent can come into his own, can find his place; but engineer-

ing is one of the best, one of the most attractive, for it is in many ways domination over the world of things. Unfortunately many highly motivated adolescents find with bitter disappointment that engineers live with numbers more than with the things they represent. Nevertheless, the things of engineering can serve as a powerful motivating force for the "self-seeking" adolescent youth.

Under the impact of any of a number of environmental conditions, a youth seeking to adjust to the other individuals in his social world—his parents, friends, brothers and sisters—may be thwarted and repulsed, rejected and denied. Finding difficult or impossible the mastery of, or the cooperation of, human associates, the youth may turn toward more controllable, simpler items, e.g., mechanical, non-social things. Gratifications obtained from success in a world of manipulatable objects may compensate for lack of gratification in primary social situations. In this way, therefore; the boy may develop an overwhelming interest and attachment for the tangible tools, techniques, and world of scientific engineering. So it might be that the motivation toward engineering serves as an outlet, displaced and distorted, of the motivation toward the social world. For this youth, his education in engineering is an education in compensation.

If, however, in the process of studying engineering, and mastering its content, the individual finds increased self-esteem, increased feelings of competence and self-worth, these may improve his social relations. Two alternatives often then arise. Recognizing engineering as the source of his social success, he increases his interest in engineering. It becomes, in effect, the stepping stone toward gregariousness. He is now one of the gang; the engineering gang.

However, it often happens that the increased social gregariousness reduces the need to compensate through engineering. Under these conditions, the youth may leave the profession—directly and suddenly—by transfer to a more man-oriented profession (medicine, law, etc.) or he may gradually evolve into the areas of business management, sales engineering, advertising, etc.

In general then, the motive which we might call the "interested in things" motive may be a direct interest reinforced by the cultural prestige of being a master of things, or it may be a compensatory readjustment toward things as an outgrowth of fear and failure in respect to people. More than likely it is a combination of both factors, as well as others, in each case.

In addition to the general pleasure obtained by having skills out of the ordinary, there is a specific pleasure of singular importance. A youth often feels an overwhelming need to have skills which are superior to those of his own father. With the general pace of technology, engineering and mechanical skills can serve to satisfy this desire most adequately. Through these forms of competence, it is as if the adolescent thinks, "Look at me; I can do things you cannot. Mother and the other important members of the family that I was dependent upon were always dependent upon you (the father) but now I can perform in manners that you cannot." The youth has gained symbolic superiority over the traditional childhood authority—the father. In other areas as well as professional engineering, it is quite common to find individuals gaining deep gratification from being more successful than their parents. This is not to say that the parent resents this. More than likely the father gains real vicarious pleasure from the successes of his sons. Nevertheless for the boy, this specific prestige over the parent may be a core motive.

Prestige in general is particularly important as a motive for entering professional life. One of the major reasons many engineers refuse to join unions appears to be the feeling that such organizations, associated as they are with "worker classes," are, in effect, reducing the pres-

tige of professional life. Often financial reward will be sacrificed, more or less willingly, to obtain such personal prestige. Where prestige is a recognition of worth, position, and importance by others, it is closely related to feelings of self-esteem and feelings of self-worth.

Largely as a result of the strong cultural emphasis on man's mastery of the environment, those symbols of such mastery—the engineers—are held in high esteem; they are prestigeful. It does not take long for a child to learn of this profession, which like medicine, is highly respected by many facets of the community. If a combination of circumstances lead the child, now an adolescent, to require prestige, engineering may often be chosen as a profession. Allied as it is with such important social labels as "scientist," "expert," "specialist," the label "engineer" may be a coveted thing, sought in its own right.

Perhaps the least clearly understood, most uniquely individual, and most complex factors sending students to engineering school are the accidental individual experiences—those experiences which seem so much a part of chance, so little a part of general socio-personal forces; e.g., the child who finds an old motor or clock in the basement and enjoys the curious pleasure of taking it apart, the boy who is called upon to aid in the high school science demonstration, the especially pleasant science teacher, the father who always wanted to be a physicist. These, and many other small and specific factors added to others more general, send a boy to engineering school for an education.

Over and above the many factors related to the stages of adolescence, and the specific individual, engineering has certain real cultural significances all its own. An adolescent might strive for gratification of basic urges through any one of dozens of pursuits. But, for the youth who chooses engineering or science, certain unique forces have more than likely made their mark.

In American culture at the present time the words scientist and engineer represent a class of persons with almost mystical qualities. They appear to design and control things beyond the wildest dreams of mortal men. The very qualities of natural phenomena that permit one to observe a television set miles from the source of entertainment are beyond the average man's comprehension. To most people, then, the engineer, who casually designs television receivers, automobiles, aeroplanes, etc. has talent, power, and merit beyond that open to most. There is a special language and the use of numbers in complicated ways. There is the ability to predict the behavior of machines, gigantic in size, power, or complexity. From the outside, engineers and scientists are powerful, often dangerous, secret people who help run the world. For many an adolescent, membership in this club is the next best thing to a trip to Mars. It is the culmination of a series of years dedicated to Tom Swift adventures, science fiction serials on T.V., automobiles, and ham radio.

Finally, and by no means least important, is the financial position of engineers in the community. They are oriented toward the commercial applicability of scientific endeavor, and are recognized by industry for their services. There are many fields into which a youth might turn to satisfy needs for prestige, status, power, mastery, etc., but very few in which all of these *plus* the desire for monetary gratification can be so nicely meshed.

Independent of the specific motives in question, each individual is oriented primarily toward his own need satisfaction. Further, he is particularly concerned with the extent of satisfaction he can expect and look forward to in the future. If the future appears full of pleasures and gratifications, the individual feels secure. If, however, there is an anticipation of danger, pain, or frustration in the forthcoming minutes, days, months, or years, the individual feels insecure. One

of the core motives for any individual can be simply called the need for security; the need to be in a position to anticipate that the multitude of lesser needs will be gratified. There are very few occupational areas in which an adolescent seeking feelings of security, feelings of a safe and satisfying future, can find them as well as in engineering. The cultural emphases upon specialized knowledges of physical processes, combined with the intellectual capacity required to master engineering, result in an ideal combination of many available jobs with a limited number of applicants. Engineering education can thus, and does, serve as a core device for the eventual gratification of a need for economic and social security.

A Recent Study

Two facets of the general problem of engineering students' motivation have been examined in a recent study (*1*). Three hundred and fifty engineering students were polled at Purdue University. From these, the results from three hundred and thirteen returns were analyzed. The students had been asked to rank in order of their importance to themselves, ten statements describing ten reasons for studying engineering. On the basis of these rankings, average importance scores were obtained for each motive statement. In order, the most important reason, on the average, for studying engineering was (1) general interest. The second most important was (2) security. This closely relates to Centers (*2*) findings which indicate that security is the prime job objective of the working class, and the second most important objective of the middle class. Following security, the Purdue students listed (3) personal aptitude, and then (4) scientific curiosity. Aptitude often leads to both curiosity and interest, since in the areas of high aptitude, one often gains the greatest feeling of self-esteem and competence, and through them, satisfaction. The need for (5) prestige was next. Following the first five was (6) monetary gain. This corroborates work done by McGregor and his associates (*3*) in the field of industrial psychology. There appears to be fairly consistent evidence to indicate that the personal satisfactions, self-esteem, and feelings of security in a job situation are more important than simple monetary income. The constant labor-management hostilities in the monetary area may reflect an absence of the higher order gratifications. Security, prestige, and self-esteem are hard to fight for; money is a tangible arguing basis.

Lower on the scale appeared (7) glamour, (8) altruism, and (9) gregariousness.

The final expressed motivation was (10) parental influence. Although perhaps the single most influential force on the child is the parent, this influence is apt to prove both subtle and in many cases distasteful. To be consciously aware of the fact that one, as an adolescent, is responding to parental pressure, is highly disquieting, and certainly deflating. Using the superficial verbal statements of the subjects, without intense clinical interviewing, it is reasonable to expect the parental pressures, no matter how truly important, to rank low.

When different groups of engineering students were compared, it was found that the scientific curiosity motive was of varying importance in the different engineering specialties. The electrical engineering students considered it more important than did any other group of specialists. The civil engineering students found it least important of all the specialist groups. Monetary gain was ranked highest by chemical-metallurgical engineers and lowest by agricultural engineers. Considering the gregariousness motive, the chemical-metallurgical engineers ranked it highest, and the civil engineers ranked it lowest.

The entire engineering teaching staff was polled and asked to rank the same ten motive statements in order of importance for students in general. The

final rank-order from the staff was correlated .90 (Spearman Rho coefficient), with the ordering from the students, indicating a high degree of staff insight into student motivation. The order given by the staff was (1) interest, (2) aptitude, (3) curiosity, (4) security, (5) monetary gain, (6) prestige, (7) glamour, (8) parental influence, (9) gregariousness, and (10) altruism. The only appreciable differences in ranking between the students themselves and the staff impressions of them, was that the staff played down the security and altruism motives, while raising the parental influence motive. These, however, were only shifts of two places.

Summary

Engineering students seem to have a pattern of motives with interest, security, aptitude, curiosity, and prestige high on the list. This pattern appears on the average to be known to engineering staff members, as indicated by a Purdue University study. The pattern itself appears to be a rather straightforward outgrowth of the general social conditions of adolescence in the working and middle classes of our culture, and seems to reflect the pattern which is generally found in studying industrial motivation.

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Servomechanisms in the Undergraduate Curriculum*

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The standard undergraduate curriculum in mechanical, electrical, or chemical engineering includes courses in mechanics, hydraulics, thermodynamics, and electricity. Regardless of the quality of such courses and of their instructors, the course content is likely to be treated as a closed entity and the interrelations of the fields of study are rarely mentioned. The student may be well equipped to solve complicated problems in a particular area but he is not able to solve simpler problems involving several fields. Too frequently, time does not permit the instructor of such courses even to mention, much less to teach, the dynamics of his subject. The student in mechanics learns $F = ma$ and $a = d^2x/dt^2$ but he never thinks in terms of $F = md^2x/dt^2$. Steady-state behavior is emphasized; transient behavior is barely introduced.

Because he is not required to exercise his knowledge of differential equations immediately following his mathematics courses, the student soon comes to believe that engineering does not require much proficiency in mathematics and resents being asked to do more than to multiply and to divide. The resulting loss of mathematical facility is doubly tragic in that creative engineering work and keeping up with one's field through reading the technical journals require extensive and increasing use of mathematics. If we admit that we are not training engineers but are giving our students a background from which they can build an engineering career, then, certainly, mathematical analysis must be an integral part of that background.

The need for improved integration of the various fundamental courses can best be met by emphasis on the dynamics of systems in an essentially mathematical course. Such a course could have a variety of names: Response of Physical Systems, Instrumentation, Feedback Control, Servomechanisms. A title including the word, servomechanisms, seems to have the most student appeal and can therefore offer the most motivation. This interest in servomechanisms undoubtedly stems from the wide publicity that feedback control systems are currently enjoying in the non-technical press as well as that due to the controversial books by Wiener. We should note, however, that the proposed standard nomenclature differs from popular usage in limiting the term, servomechanism, to those feedback control systems in which the controlled variable is mechanical position.

H. L. Hazen of MIT wrote in the *ASEE Journal* for October 1947 an apt description of the educational advantages of the feedback control field. "We find in practice that it becomes an extraordinarily effective medium for deepening and broadening the grasp of fundamental principles. Thus one immediately comes face to face with the dynamics of lumped-parameter systems including active elements. Questions of dynamic stability and of detailed behavior under transient as well as steady-state conditions must

* Presented at the Annual Meeting of the Upper New York State Section of ASEE on October 23, 1953.

be answered quantitatively. One finds that the steady-state response to periodic driving forces over a broad frequency range is equally important.

"This type of analysis, of course, requires the accurate description of the behavior of the significant elements in terms of differential equations, one of the most difficult and simultaneously most important components of the engineer's discipline. In a servo system one encounters separately or in combination such apparently diverse devices as: electric circuits including electronic devices; hydraulic amplifiers, pumps, motors, and transmission systems; pneumatic systems; and electro-mechanical devices, including motors, generators, torque motors, selsyns, multi-winding amplifier generators; to say nothing of the chemical, thermal, aerodynamic, mechanical, or other systems which are integral components of closed-cycle systems for the control of such quantities. The servo man must be able to deal quantitatively and analytically with the dynamics of such varied components and of complete systems involving them. Thus the servo field is one that compels integration of mechanics, hydraulics, and electric circuits in a way that is a joy to the educator."

Historically, due to the similarity of feedback control systems and feedback amplifiers, most courses in Servomechanisms have been offered in electrical engineering departments. For such a course as I am suggesting in the undergraduate program, I feel that the student will gain by taking the course from an instructor not of his own department; in this way both the instructor and the student are forced into more use of analogy and the viewpoints of both receive the maximum growth. Having students with diverse backgrounds in a single section is similarly advantageous.

Essential Prerequisites

The essential prerequisites include mathematics through differential equations, analytical mechanics, fluid mechanics, and an introductory course in electrical engineering. Unfortunately, few, if any, students have completed all of these before their senior year. I say "unfortunately" because I believe that the value of every course taken after a broader viewpoint is obtained is greatly increased. If it were possible to make the freshman fully aware of the common mathematical stem which runs through most of his later work, our task as teachers would be both easier and more rewarding and the mental barrier of the student toward work outside his chosen field would be materially weakened.

Although I realize the present crowded condition of most curricula, I still have the courage to ask that no less than four and preferably six semester hours should be devoted to feedback control systems as a strongly recommended, if not required, subject in the senior year. In such a course twenty percent of the time might be allotted to the setting up of differential equations and system analysis by block diagram; twenty percent to simple proportional, derivative, and integral control systems solved by classical methods; fifty percent to the interrelation of the time and frequency domain including transform mathematics, the impedance concept, the Nyquist and Bode treatments of the stability problem, and the root locus method; and the remaining ten percent to some elementary cases of non-linear systems. Although most units of real equipment are linear only over narrow ranges if at all, the undergraduate course should concentrate on the linear system because it can be handled in a more general sense and because even its concepts are new to most seniors. The inclusion of one or two non-linear systems, however, will serve to remind the student that he still has much to learn!

Although the use of demonstration systems is certainly valuable, no student laboratory work is essential in an undergraduate feedback control course. If more time than the minimum four semester hours is available, inclusion of lab-

oratory work is both feasible and desirable.

At the University of Rochester, a six-hour elective course is open both to seniors and to graduate students. Approximately ten percent of the senior mechanical engineers take this course and their reaction to the material has been most gratifying. The present enrollment includes seniors in mechanical engineering, physics, optics, and mathematics, and graduate students in chemical engineering and optics. The same course is given in the extension school and has been well received by engineers from local industries many of whom are engaged in part time graduate programs.

In March of 1953, an "Instrumentation Conference" was held at Michigan State College under the sponsorship of this and other organizations. It seemed to me that the principal theme of the meeting was the need for all engineers to have some familiarity with the dynamics of systems and devices. Many of the industry speakers, unaware of the academic realities, indicated that every graduating engineer should be a specialist in instrumentation. This cannot be. But we can, and I hope we will, subject increasing numbers of our undergraduates to the great integrating influence of the automatic feedback control field.

In the News

ECPD Survey on Awarding Professional Degrees

The Recognition Committee of the Engineers Council for Professional Development, under the chairmanship of H. R. Barclay, has completed a survey of the awarding of the professional degree by various engineering institutions. The survey, with its excellent response—of the 146 institutions sent questionnaires, 142 responded—will serve as a basis for formulating recommendations concerning the practice of awarding the professional degree as a means of professional recognition.

Of the engineering schools surveyed, 86 award the professional degree while 62 do not. Of the 86 awarding the degree, 74 use professional experience as a basis for awarding the degree, 8 require resident graduate study and 4 include both professional experience and resident graduate study as prerequisites for awarding the professional degree.

In regard to their future plans concerning the professional degree, 69 colleges will continue awarding the degree, 2 will institute the professional degree, 13 will abandon it, 49 will continue not to award it, and 17 are uncertain as far as future plans are concerned. The survey shows that approximately one-fifth of the schools offering the professional degree have either dropped it or are making plans to do so.

The Committee also reported an increase of approximately 80% in the awarding of professional degrees in the last five years as compared with the previous five-year period. In the last 10 years, 1387 to 1398 professional degrees have been awarded, and of these, 917 to 922 have been awarded during the last five years.

The Committee believes this survey to be the most comprehensive of its type ever undertaken and will use it in formulating recommendations on the practice which they believe should be followed in respect to awarding the professional degree as a means of professional recognition. Copies of the report can be obtained from ECPD, 29 W. 39th Street, New York, N. Y.

The University Contribution to the Success of an Engineer

By H. E. HOELSCHER

Assistant Professor of Chemical Engineering, The John Hopkins University

Author's Note: The ideas presented in the following paper are not entirely original with me. They may not have been entirely original with the man who presented them to me so many times during our acquaintance. However, he did more than anyone I have ever known to convince me of their validity. I, therefore, acknowledge here my debt to Professor R. S. Tour, late Head of the Department of Chemical Engineering of the University of Cincinnati. Professor Tour was, in my opinion, an engineer of the very highest calibre and a teacher of great effectiveness. I respected him for his honesty, his ability to think clearly, concisely, and effectively, and for his fairness and integrity. This paper, then, presents certain ideas concerning that which is required of a successful engineer, ideas which Professor Tour considered completely valid and which I have come to accept in the same manner.

Success in the field of engineering implies different things to different people. To some it means a high position in a company of recognized standing. Money and authority accompany such a position and cannot be considered as separate goals for those interested in striving in this direction. To others, the word success means advanced specialized knowledge and the contributions to human understanding which accompanies the use of knowledge. An almost infinite variation in shades of meanings are to be found betwen these two extremes.

Whatever the personal interpretation put upon the word, whatever the goal a man sets for himself as he graduates from the university of his choice, there are four requirements for his achievement of that goal. These are:

Ability to think
Knowledge
Personality
Luck

Knowledge must be present when a problem is presented and a solution demanded. An ability to think is necessary to use that knowledge effectively. Without this requirement, many of our electronic computing machines should be classified as successful engineers. Personality will largely determine acceptance by and into society and is of importance in developing an ability to handle people. Finally, there are many occasions when nothing more than luck is involved. Being in the right place at the right time can sometimes mean more in terms of opportunity than all of the others.

Of most interest to those in the business of training young engineers for success in the respective fields of specialization is the fact that they can provide their candidates with only one of these four prerequisites—and that in sadly limited quantities.

The ability of a person to use his mind for objective and/or creative thinking is

very likely fully determined by the time he reaches the age at which he enters the university. His personality has been formed by his home environment—many psychiatrists feel within the first few years of his life. The teacher of engineering can do little to provide his student with a personality for success. And, certainly, the professor has no formula for luck—unfortunately.

Instilling Knowledge

Thus, we are limited to the job of instilling knowledge—or, better, and more truthfully, to the job of instilling a desire for knowledge and a recognition of its value—hoping in so doing that the student will see to its acquisition by himself.

There is, perhaps, another task—sounding not nearly so lofty when set down in words, but still of importance in terms of a job to be done. This is the task of selecting, from among the many, those few who are potentially able to contribute significantly to the progress of the professions and to give these men assistance and the opportunity to develop their latent capabilities in the hope that they will make significant strides forward during their time.

Briefly then, those engaged in the teaching of potential young engineers can do no more than take (after having found) those who would likely become successful anyway—in spite of all their professors can do—and implement their progress by providing ready tools with which to work. These tools are, by and large, ineffective in the hands of those who have not already the ability and personality to make the most of them. For the remainder they provide only a means to a desired end.

The Teaching of Report Writing: A Cooperative Program*

By ISRAEL SWEET

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AND

KENNETH E. QUIER

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The Question of Need

Engineering curriculums are planned within restrictive time limits that are basically common to all curriculum design. Such a limitation has required necessarily that a concentration on some knowledges and skills be stressed at the expense of omission or subordination of others. Thus, a key question faces educators at work on course development: "What does the student need most of all?" The answer to this helps to determine what he is offered, how much of it he is offered, and when and in what order he is offered what it is judged he needs.

If industry has been correct in its appraisal of what the engineer requires by way of skills, then one skill (plus the associated knowledge) that we can be certain engineers need is the skill of communication: he must be able to effectively manage its content, media, and methods. The engineer is very clearly involved in the post-war re-orientation of industrial management to the need for clear communication as an organizational postulate. Indeed, the engineer fails in his primary function unless he is capable of fulfilling that function through communication. He must, by nature of his position (which has become increasingly administrative and supervisory), be able to transmit to varying audiences (ranging from the extremely technical and specialized to the relatively non-technical and generalized), through selective media, his information, findings, solutions, conclusions, recommendations, and decisions. Without this ability, the talents of the engineer become unusable; his unexpressed notions might just as well not exist.

The major medium of communication for the engineer in his formal organizational role is the oral or written report. Therefore, it is obvious that the engineering student must be taught the skill of reporting prior to his entry into his professional world.

At Pratt Institute, we have concentrated on the written report problem as a matter of practical decision. We believed that there could be more profitable collateral learning of oral report principles through practice in writing than if the process were reversed. This does not mean that the speech job can be handled adequately through instruction in the writing phase. We simply hoped for leakage of ability from one area into the

* This article is a condensation and revision of the paper presented at the 61st Annual Meeting of the American Society for Enginering Education: Mechanical Enginering Conference (Machine Design and Manufacturing Processes Subdivision), June 26, 1953, at the University of Florida.

other. Our sights narrowed because we had what time we had, and no more.

We established working standards for communication effectiveness. They were not intended to be spectacularly original or revolutionary, so much as they were intended to be conventionally acceptable as accurate and valid. The engineer, we believed, should know (1) business correspondence form and content requirements: (2) technical report form and content requirements; (3) the relationship between reports and correspondence; (4) style requirements and adaptations for reader needs; (5) principles and practices of grammar, punctuation, and planning; (6) types of reports and correspondence relating to routine and non-routine industrial activities; (7) methods of critical revision; (8) methods of fact-finding, evaluation, organization, content preparation, and manuscript arrangement; (9) *and, above all, the means of creating a professionally acceptable report out of a working situation existing in an engineering context.*

Items (1) through (8) are matters of information-giving and exercise. Item (9) is a matter of situation and motivation. We had to manage to develop that knowledge realistically. It is one thing to offer information to the student, tagging on to that information persuasive devices of one kind or another which it is hoped will assure the student that, sometime in the future, late or soon, he will be in a position to use that information. It is quite another thing to reproduce (as far as circumstances permit) the conditions which demand the meaningful use by the student of the information being submitted to him. With this second possibility, we hoped to see the direct translation of classroom knowledge into some real aspects of engineering working techniques.

Our problem in planning the report writing course became a set of questions: How can report writing be taught so that the enginering student will have to grapple with the report problem in terms similar to those which he meets on the job? How can we produce the atmosphere, the supervisory apparatus, the problem-solving requirement of the industrial plant? How can we put the enginering student to work as an engineer who faces the submission of a report?

If we could get the answers to these questions, we would get the course we wanted.

Our answers worked out in this formulation. The student should be doing a job of project investigation and development on an industrial job basis. He should be faced with a realistic as against a make-believe job. He should be an "employee" working within the framework of organizational relationship and responsibility. Thus, it became clear that we would have to "hire" the student. We would pay him in course credits. And his job with us would be of a most temporary nature. However, we felt that his real earnings would be contained in the functional skill that has lately come to be described in the fashionably modern term, "know-how." (We were not attempting, in any way, to plan a course type requirement, the "thesis" problem, that has fundamentally different purposes than those we aimed at. Therefore, this paper does not describe in any way the senior thesis requirement in force in many institutions.)

Meeting the Need: The Research Institute Plan

In the spring of 1950, two separately conceived courses of instruction were integrated by imposing upon them a working organization named the *1950 Research Institute.* The date numerals have been changed from year to year. The "Research Institute" plan represents an attempt to create a professional working organization within an academic environment. Its organization is relatively simple. The program revolves about two co-requisite courses offered to senior mechanical engineering students: Mechan-

ical Laboratory (ME 432) and Reports and Correspondence (Engl 492). The Chairman of the Mechanical Engineering Department serves as the "Director." Members of the Mechanical Engineering Department who instruct in ME 432 are "Project Engineers." English Department instructors of Engl 492 constitute the "Editorial Staff." Senior mechanical engineering students are the "Junior Engineers" (or "Technicians").

The operations of the Research Institute involve the issuance of investigative or developmental projects to the Junior Engineers who work on those projects under the supervision of the Project Engineers. The Editorial Staff directs the Junior Engineers through the report requirement which is ultimately submitted in duplicate to the Editorial Staff member and the Project Engineer. The Director administers the combined operations of the Institute by coordinating policy, procedures, operations, and standards. The teaching staffs utilize periodic conferences, at two-week intervals, for discussion of problems. Lines of communication for the Junior Engineers are directed through the Project Engineers or the Editorial Staff to the Director.

The Research Institute plan centers on translating for the student a series of general requirements into specific informations and techniques: (1) the formulation of engineering plans for a specific project; (2) the purposeful development of those plans aimed at achieving specified results; (3) the estimation and evaluation of findings; (4) the use of an actual purchasing system for materials procurement; (5) the submission of progress memoranda at stipulated intervals; (6) the presentation of written and oral technical reports which meet established standards.

It is to be noted that ME 432 and Engl 492 have been conducted as distinct courses. They meet at different hours during the week in separate classrooms: ME 432 for one class and six laboratory hours; Engl 492 for three class hours. Thus, each course has received its own stresses and has followed its own sequence of material and patterns of development controlled by differing course contents. Individual departmental views receive independent treatment, although such views tend to become related through the Research Institute. Integration has not meant the administrative enslavement of one department of instruction by another, a bugbear belonging to the skeptical.

The Report Writing Phase

Engl 492 was planned with two controlling purposes: (1) to train the student in the disciplines of reports and correspondence preparation, and (2) to provide a realistic link, through course arrangement and direction, of the substance of Engl 492 to the larger organizational operation embodied in the Research Institute.

We use two textbooks, which provide separate aspects of content and sometimes overlap in coverage, as the working bases for class discussion of material concepts. The 45 hours of class time are distributed in this way: introduction (1 hour); discussion of technical style (1 hour); report writing requirements (1 hour); correspondence types (6 hours); correspondence form and layout (2 hours); correspondence style (1 hour); grammar review (2 hours); technical composition forms (4 hours); technical diction (2 hours); report style (5 hours); library resources (2 hours); fact gathering (2 hours); report planning (2 hours); report layout (2 hours); visual aids (1 hour); sample report study (5 hours); oral report techniques (1 hour); oral reports (5 hours).

A special assignment schedule is issued to each student at the start of the semester. It informs him that, in addition to four routine written assignments (three business letters and one general piece of expository writing), he will have to submit eight inter-office memoranda (with specified attachments)

and one 2000-word (minimum) examination report. Work standards have been set up rigidly as organizational standards of the Research Institute. The quality stress requires that the student view himself not as a "student" but as a working engineer dealing with a job requirement.

The series of letter assignments constitute a sequential set of letter reports, functioning as progress statements in relation to the project job being undertaken in ME 432. In Engl 492, the Editorial Division is in effect leading the Junior Engineer through the stages of planning, writing, and editing of the report which is a terminal requirement in both courses. All correspondence is submitted typed, in duplicate to the Editorial Staff. Hence, copies of all correspondence go to the Project Engineer. The previously mentioned staff conferences permit co-operative control and direction to be exercised upon the student's handling and expository treatment of his project problem.

The letter assignments are spaced a week apart and require that the student (1) present a tentative statement of his project problem; (2) present a final statement of the project problem; (3) list the sources of information for the report; (4) define the subject, purpose, and scope of the report; (5) present a detailed outline of the report; (6) prepare an analysis of the introductory sections for the report; (7) write a first draft of the introduction; (8) submit the title page and table of contents. The final report is submitted at least two weeks prior to the end of the semester.

The Mechanical Laboratory Phase

ME 432 has been planned to train the student in (1) direct methods for formulating plans and procedures for specific engineering projects; (2) carrying out projects to satisfactory completion; (3) methods of evaluating the results of project developments; (4) methods of materials procurement and purchasing system requirements; (5) professional requirements for reporting.

Projects are formulated in the light of four realistically limiting factors: available facilities, student interests and capacities, the fulfillment of course requirements, and time. Project ideas have been developed from the suggestions of various technical departments or administrative offices of the school, from interested industrial organizations, from trade literature or professional journals, and frequently from the students themselves. Since the Research Institute plan goes into operation in the spring semester, the students are briefed by the Mechanical Engineering staff in the fall semester about the need for surveying project possibilities. The briefing includes an outlining of the Research Institute organizational plan, the co-operative aspects of the two courses, and the nature of objectives and requirements necessary to meet those objectives. Typical work projects which have been treated are these: (1) time and motion study of paper box manufacture; (2) the study of the electro-mechanical analogy as applied to a vibrational absorption unit; (3) the redesign and proposed method of manufacture of a Bostitch Wire Stitching Machine arm; (4) the study of re-inforced concrete beams compared with prestressed concrete beams; (5) the study and test of a steam wind tunnel.

In general, the ME 432 course has concentrated upon getting the Junior Engineer started on his problem and seeing that he keeps going in a reasonably promising direction. A carefully planned system of controls and checks has been effected to insure that the novice engineer will not get lost in a cloudy corridor. In a sense, the function of the Project Engineer is largely catalytic: he devises workable means for stimulating and orienting students continuously so that projects will operate at maximum efficiency. Supervision during laboratory hours and free discussion during the recitation hour (dealing with technical problems to be

solved) facilitate recognizable progress.

In addition, the student gains clarity throughout the project through the discipline of required regular submission of memoranda to the Project Engineer. After the initial selection of a project topic, each student is required to submit a statement which describes the investigation to be made, and an outline of the procedure to be used for the design, construction, and testing which would be undertaken as project requirements. The Project Engineer then discusses the statement with the student, attempting to modify, where necessary, the nature and scope of the project based upon practicability and student capacity or ability.

Once the project is acceptably formulated in a written statement, it receives a project number and title. At this point, the statement of intention is presented to the Director. Further scrutiny and evaluation results ultimately in the issuance of a contractual memorandum concerning the aim of the project and particular commitments. The Junior Engineer is then able to proceed in the direction and towards the end agreed upon.

Progress reports, initiated at this point and submitted at stipulated periodic intervals, permit control by the Project Engineer to be exercised further. All memoranda are approved only when inspection of work on the project tends to substantiate the statements of the memoranda. The work project itself and the final report are graded by the Project Engineer in terms of his requirements.

Conclusions

Three points-of-view are pertinent regarding the validity of the instructional method embodied in the "Research Institute" plan of instruction in report writing: those of the English staff, the mechanical engineering staff, and the students who have participated in the program. Conclusions are expressed in summary statements reflecting individual group emphases.

The English Staff

Conclusions relate to the values derived from the cooperative nature of the course:

(1) Student motivation is effective and immediate.

(2) Academic information becomes directly translated into "doing." No distortion of content occurs because "time-lag" is virtually non-existent.

(3) A sense of professional standards is carried to the student realistically.

(4) The student gains an integrated view of the report writing process. He can follow his report in action from earliest project planning stages to project completion.

(5) Inter-departmental collaboration permits the teaching staff to gain a broadening concept of technical reporting and consequently a release from academic provincialism.

The Mechanical Engineering Staff

These conclusions exist:

(1) The student gets the "feel" of actual engineering problems and the necessity for precisely stating those problems.

(2) The student learns functional procedural methods in approaching project analysis and development. He thus "previews" his later professional work.

(3) The student learns the need for realistic engineering *planning.*

(4) The student learns to use purchasing procedures and to estimate time required in materials procurement.

(5) The student learns to initiate and to develop effective experimental procedures and to carefully record *all* data associated with such procedures. He particularly learns to observe and to evaluate experimental data in accordance with scientific methodology applied to a job.

(6) The student learns the significance of organizational systems and procedures.

The Students

In April, 1953, a questionnaire, pointed to the evaluation of the combined course

program, was mailed to 122 graduates who, as senior mechanical engineering students, had been working members of the Research Institute at some time during the spring semesters of 1950, 1951, and 1952. Sixty-four of the questionnaires were returned, constituting a 52½% response. Replies were requested to be submitted anonymously if preferred. The following summary constitutes a grouping of the most pertinent remarks:

(1) 71.9% of those answering, in their present jobs, had to prepare internal memoranda or reports, either "regularly," "often," or "very often."

(2) 37.4% had to prepare external letters or reports, either "regularly," "often," or "very often."

(3) 89.1% of those replying believed that the combined course provided "actual value in terms of helping you meet job needs."

(4) Replying to a question about the values of each of the two courses, considered separately, 71.8% generally considered that Engl 492 had helped them meet job requirements for effective report organization and presentation. Most of the remaining 28.2% presented miscellaneous values received, somewhat linked to the majority conclusion. 65.8% considered that ME 432 had prepared them to effectively handle industrial project planning and development work. Most of the remaining 34.2% listed values somewhat related to this objective.

We are "sold" on this cooperative course plan. It has worked successfully for us and apparently for our graduates. Of course, this is not the only way to teach report writing. And it is likely not as good as some other ways. We simply recommend this program as a workable means to a good end.

A Public Relations Program for the Engineering Profession

By GERALD K. GILLAN

Professor of Civil Engineering, The Pennsylvania State University

Much has been said, and a little has been done, in recent years, about the universally recognized deficiency of the engineering profession commonly referred to as public relations. We admit to having poor public relations—for we continually talk of improving them. From the purely selfish point of view, a wisely conducted program of public relations is a good investment, for it leads ultimately to improved financial rewards for each member of the profession. More important to the truly professional minded person is the increased responsibility that comes with proper recognition, and the broadened opportunity to be of service to society.

Definitions of public relations are found to be numerous and varied. A noted brief definition is, "Public relations is being good and getting credit for it." Princeton's Professor Childs says, "Public relations is simply a name for those activities and relations of ours that are public and which have social significance." Wright and Christion [1] state, rather thoroughly, "Modern public relations is a *planned program* of *policies* and *conduct* that will build *public confidence* and increase *public understanding*."

The latter definition should appeal to the orderly minds of engineers. It is the basic thesis of this paper that a planned program of public relations is essential. The question that now presents itself is who shall do the planning and who the execution of the plan? Certainly it is evident that individual efforts, no matter how sincere, can not accomplish the task of establishing proper policies for the profession or proper conduct for each member of the profession. It seems evident to the writer that a modern public relations program must be planned and conducted by a unity organization of engineers, and that only such a unified action can hope to be truly successful. How critically important it is that unity of the profession be accomplished as soon as possible! Without it, the best efforts of segmental groups toward better public relations will continue to be largely vitiated by internal wrangling and almost child-like squabbling.

Various Publics

Before proceeding further, perhaps it would be helpful to consider the nature of the "publics" with which the engineering profession wishes to establish and maintain good relations. It may come as a surprise to a few readers that there is not merely one big all-encompassing "public," but many "publics." Among the various publics the engineering profession must consider are:

1. Prospective students of engineering.
2. Parents of prospective students.
3. Teachers of prospective students.
4. Students in engineering schools.
5. Parents of engineering students.
6. Engineering school faculties.

[1] "Public Relations in Management," Wright and Christion, McGraw-Hill, 1949.

7. Employers of engineers.
8. Employees of engineers.
9. Sub-professional engineering societies.
10. Technical engineering societies.
11. Professional engineering societies.
12. International engineering societies.
13. Foreign engineering societies.
14. Governmental agencies, local, state, national.
16. Other professions.
17. The general public.

The preceding list is not complete, but it may indicate the scope of the proposed program which will improve relations with so many varied publics.

It seems obvious that many of the publics must be contacted, not directly *by* a professional-unity organization, but *through* state and local representatives of a national (or inter-national) unity group. This conclusion certainly suggests the validity of recent arguments favoring a unity organization which is integrated from top to bottom at the local, state, and national levels.

The foundations of good public relations already exist in the engineering profession. The profession has existed for many years and has maintained an excellence of performance, a high standard of ethical conduct, and an encouraging growth of educational background that should make us all proud to be known as professional engineers. We know the profession is good. Getting credit for it is the problem.

It is not intended that any reader suppose that a high-powered press-agent is the answer to our needs. Public relations as a professional field is still recovering from the bad taste in the mouth left by many an irresponsible press-agent. The real instruments of public relations are *people*. Naturally, *people* as individuals can help or hinder. It follows that enlightenment of the individual member of the engineering profession, emphasizing his critical place in the planned program, is essential to the execution of a modern public relations program.

Long-Range Continuity Necessary

It is contended that planning a program of policies and conduct must be undertaken at a national level. Such a plan would be long-range and should reach lower levels not by osmosis but by a direct and easy route. It is not enough to send the word down the line once, to be forgotten when a new set of officers take over. A continual planned program must be formulated and executed. Launching the thing will require prior education and acceptance of key groups, at all levels. But long-range continuity must be maintained.

At this point, delegation at the state and local levels becomes essential. Group efforts and individual efforts must be directed and coordinated. Information must be readily passed down the line to keep local groups and individuals on the right track. Information on group and individual activities must move up the line so the guiding agency can keep in touch with progress and action at the lower levels.

Continual re-evaluation will be required. Aims and activities may change, or emphasis may be shifted from one to another. Operation of the plan is a terrifically important function. It must be in the hands of leaders who devotedly seek to improve the profession. Their ideas and ideals must correspond identically with those of the unified profession.

This plan would be no small thing. As a matter of fact, it borders on the monumental. How better could the engineering profession accomplish its goals than to seek the advice and guidance of professional public relations men? Let us retain an outstanding public relations firm to formulate a plan and aid in its execution and advise on its long-range

maintenance. Theirs is a young profession, but it is a recognized profession. How can our consciences rest if we fail to recognize them—especially when we stand to gain so very much.

This paper has a very simple purpose. It presents a course of thought and action which, if followed with reasonable faithfulness, should result in public relations that will be beneficial to the entire engineering profession and to the individual engineer as well. Men in engineering education are both members of the profession who will benefit and members of one of the most important "publics." They can be leaders in a modern public-relations program, or they can sit in their ivory towers and let others do it.

The Role of Graphics in Engineering Education*

By FRANK A. HEACOCK

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The purpose of this paper is to show the value and importance of graphics as an essential part of engineering education. The scope of the subject is broad enough to include not only the basic graphics courses in engineering drawing and descriptive geometry, but also the advanced graphics courses and other courses in the engineering curriculum that may be taught most effectively when graphic methods are employed. To understand and appreciate the educational value of graphics, we must appraise its objectives and realize the significant benefits that the engineering student derives from a well-rounded program of graphics instruction.

Graphics is both an art and a science. Considered as an art, the most popular form of graphics is engineering drawing, which has become the universal method of recording and communicating information in the engineering profession. Our industrial success is due in large measure to efficient planning on the drawing board. The more complex the production problem, the more urgent is the need for effective drawings to show the workman exactly what is required. As future progress in industry and technology will depend more than ever upon better working drawings, the drawing teacher today accepts the responsibility of giving engineering students the right kind of drawing instruction, so that the engineer of tomorrow will have the best working knowledge and drafting ability to plan future developments.

The widespread usefulness of engineering drawing and its importance as a vital factor in industry overshadow its other educational functions. When properly taught engineering drawing does more for the student than develop drafting skill. It is the freshman's first professional course and it trains his mind as well as his hand and eye. While he is learning to make drawings that conform to accepted standards of drafting practice, the student acquires the ability to observe intensely, to visualize and think constructively in three dimensions, and to express his ideas by means of technical sketches. The development of correct thinking habits in relation to the planning, drafting, and interpretation of drawings and technical sketches is an important objective in the teaching of engineering drawing.

Sound Structure of Logical Reasoning

The science of graphics is introduced to the student in descriptive geometry, which provides graphic solutions for a wide range of three-dimensional problems involving form, position, direction, size, and geometric relationships. The transition from engineering drawing to descriptive geometry is a natural one, because both are based upon the same system of representation, orthographic projection. On this foundation descriptive geometry builds a sound structure of logical reasoning, established facts, and realtistic planning which culminates in an accurate solution on the drawing board. It puts into practice the engineer's method of thinking each problem through to a successful conclusion. It

* Presented at ASEE Annual Meeting, University of Florida, June 1953.

trains the student to analyze a situation step-by-step, to organize his thoughts and direct them toward a definite objective. It exercises the imagination and it promotes the growth of the power of visualization. Descriptive geometry provides an excellent introduction to the study of graphics as an analytical tool.

An important feature of descriptive geometry is the direction of sight, the choice of a strategic point of view from which the problem may be seen to best advantage. Thus a line may appear as a point or a plane may show edgewise as a line in order to reveal true distances or relationships. The new facts discovered at each viewpoint build up the mental picture until it becomes a complete realization. In the analysis of problems by descriptive geometry methods the student learns how to size up a situation from any desired angle. The nimble, mental shift from one point of view to another makes the mind supple and stimulates the imagination. It gives the student a confident sense of direction when dealing with complex problems in our world of three dimensions. It orients his thinking, makes him resourceful, and develops good judgment in the selection of methods of solution.

In engineering education it is the responsibility of the graphics teacher to help the student develop a graphic mind, which is an asset of great value to the student while he is in college and after he enters his profession. Let us consider the graphic mind to determine what it is, how it works, and what we should do to develop it more effectively. It will be helpful to analyze the learning process and show how the graphic approach makes it easier for students to understand the theory involved in the difficult courses in the engineering curriculum.

Visual Aids to Learning

Educators agree that the eye is the open door to the mind. Students acquire many forms of knowledge more rapidly from pictures and demonstrations than from the words they read in textbooks or hear in lectures. Therefore visual aids to learning are popular in all branches of education. Most students are picture-minded and they prefer textbooks that are full of clarifying illustrations. A good picture is worth a thousand words because it tells its story at a glance. In engineering textbooks, however, pictorial illustrations are not always adequate. When the subject to be pictured is complicated, and particularly when its interior construction must be shown, two or more related orthographic views are necessary to convey the full meaning. Or the text discussion may require a different kind of illustration, such as a graph, diagram, or contour map. If the student has actually drawn similar graphic representations, he can interpret these illustrations quickly and with complete understanding. Personal experience on the drawing board with the various graphic methods is the minimum requirement for a graphic mind.

The engineering student devotes a large part of his first two years in college to the study of mathematics, chemistry and physics. These basic courses provide a background of fundamental principles that are essential to all engineers. Such courses are usually taught by faculty members who have no engineering experience and there is a tendency toward the abstract approach. As most engineers dislike abstractions, the student who is developing a graphic mind has an advantage in his own concrete approach to learning, even where no graphs are employed in text or lectures. Engineering drawing has sharpened his perception by requiring him to visualize the form, proportions, size, position, and function of physical objects. Then his mental vision has been deepened and made more adaptable by the analysis of geometric relationships in the study of descriptive geometry. This rewarding experience helps him to develop a keener insight, which he can apply to his stud-

ies to gain a firm grasp of the fundamental principles of mathematics and science.

In the development of engineering education a group of mechanics courses has become the backbone of the curriculum. Engineers must study statics, strength of materials, dynamics, and fluid mechanics to gain a working knowledge of their fundamental concepts. In this setting we can describe the graphic mind and show how it attacks engineering problems. It is a versatile type of intellect that is constantly aware of the graphic nature of things and instinctively pictures ideas in terms of geometric figures.

In the study of statics, for example, we have the basic concept of force which has the properties of magnitude, direction, and position. The mind pictures a force as a vector, a straight line with an arrowhead on it. When drawn to scale the length of the vector represents the magnitude of the force. The direction of the vector is made parallel to the line of action of the force, and the arrowhead shows which way the force acts. If several forces act at a common point, the vectors that represent them are drawn to scale in consecutive order and direction to form a closed polygon called a vector diagram. The closing vector which completes the diagram gives the magnitude and direction of a force that will hold all the other forces in equilibrium, a force equal and opposite to their resultant. If the forces involved do not lie in the same plane, two orthographic views of the vector diagram are necessary. In such cases the methods of descriptive geometry are used to determine three unknown forces which act at a common point with a known force, for a system that is in equilibrium. Graphic statics provides a well developed procedure of graphic analysis for accurately determining in one continuous operation the stresses, or internal forces, in all members of framed structures. Graphic statics deals with bodies at rest, but the vector principle is also a powerful tool for solving problems involving motion. In kinematics, for example, vectors are indispensable for representing displacement, velocity, and acceleration, which form a solid base for the study of all mechanisms. Each course in the mechanics group offers abundant opportunities for the application of graphic methods. The solution of mechanics problems by means of vectors and related diagrams clarifies the basic relationships and gives the student a better understanding of every factor involved.

Creative Ability

Engineering colleges are expected to develop a program for the training of engineers with ability to do creative work in the field of engineering design. Creative ability calls for originality, resourcefulness, ingenuity, and a constructive imagination. These essential habits of thought can be developed by a progressive program of instruction in graphics. The constructive thinking habits established by graphics courses at freshman level form a sound foundation for continued development of creative mental vision. This may be furthered by requiring the student to make frequent use of graphic methods in subsequent engineering courses. Facility in devising and applying graphic procedures wherever they can be employed to advantage is a necessary skill in all branches of engineering. In advanced courses a series of functional sketches provides the essential framework for the progressive development of ideas in projects designed to promote creative thinking. By clarifying relationships and by revealing possibilities for further development, each sketch gives a better grasp of the problem and becomes a springboard for accelerated progress. Instead of learning how to do specific things in a limited area, the student acquires the ability to solve new problems in unusual situations. Thus the project method, reinforced by a full utilization of graphic

aids, offers most promise in college training for the creative practical phases of engineering design.

As education and research are closely related, each helps the other, particularly at the graduate level. Teachers of engineering drawing and descriptive geometry can render a valuable service by acting as advisers to graduate students who are working on thesis projects and by assisting colleagues who are engaged in research. This arrangement facilitates the graphic analysis and interpretation of experimental data. Actual experience in setting up research problems and solving them by graphic methods leads to the discovery of important unsolved problems that challenge our best efforts. The versatility of the graphic approach has been demonstrated in recent research projects. Professor A. S. Levens at the University of California has applied graphic analysis to the successful development of a greatly improved artificial leg for veteran amputees. And at Columbia University Professor H. W. Vreeland is using descriptive geometry methods in the accurate control of radium dosage in cancer therapy. These significant achievements challenge the graphics teacher to devote his talents to research projects in science and engineering.

The future of graphics is of interest to all of us. How will engineering drawing and descriptive geometry be taught twenty years from now to meet the changing needs of engineering education? It is a safe prediction that these courses will widen their scope in order to keep pace with the expanding pattern of graphic applications in industry, science and technology. To make the best possible use of available teaching time the problems in engineering drawing should be consolidated to eliminate repetition and duplication of effort. Each problem may well combine many new characteristics of instructional value to the student. In order to simplify drawings and make them easier to read with full understanding, we shall probably adopt an abbreviated method of drafting and dimensioning, featuring the omission of unnecessary details, which will save valuable time on the drawing board. Drafting standards will be revised in keeping with the more efficient drafting methods required by industry.

Technical Sketching

Courses in engineering drawing will devote more time and greater emphasis to technical sketching. The student should acquire facility in making functional sketches in various technical applications. The drawing project method will offer the future engineer actual practice in developing a real problem which will awaken new interests and stimulate the motivation that spells success in engineering. Affording opportunities for creative thinking, each project would require a systematic approach to the best solution of the problem through the medium of the idea sketch and progressive development sketches. Good judgment will be reflected in the final design sketch and its companion working drawing. Thus the drawing project would give the student the right start in his college training for the design function of engineering.

What future changes are likely in the teaching of descriptive geometry? This applied science provides the necessary background for the study of graphics as an analytical tool. Future courses in descriptive geometry may well condense their treatment of intersections, warped surfaces, and axonometry in order to save at least a third of the teaching time which should be devoted to problems in advanced graphics and an introduction to graphic analysis. This new material should be closely coordinated with fundamental problems in the various mechanics courses and in specialized fields of engineering. Many technical investigations dealing with forces, motion, velocity, and acceleration are based to a large extent upon

the use of vectors and related geometric constructions. Wherever the problems involve three dimensions the methods of descriptive geometry can be applied to advantage. An introduction to graphic methods of computation, such as nomographs and graphic calculus, would give the student greater confidence in these useful tools when he encounters them in subsequent studies. Applications of graphic principles to the interpretation of experimental data should be included in the new material of analytical graphics. The illuminating experience of step-by-step graphic analysis will give the student tangible verification of fundamental concepts and require orderly, effective reasoning. This wider scope of instruction will enhance the value of graphics in the education of future engineers.

Many interesting articles have been published in recent technical journals describing new applications of graphics to the solution of technical problems in various fields of engineering, science, business and industry. This widespread awakening of interest in graphic methods offers a challenge to the teachers of graphics. I would like to urge my colleagues to explore the fertile fields of advanced graphics and to engage in graphics research projects of a fundamental nature. This fruitful personal experience will enrich their teaching of the graphics courses and strengthen the role of graphics in engineering education.

Effective Counseling for Engineering Freshmen

By ROBERT L. RITTER

Assistant Professor, Dept. of Engineering Drawing, Marquette University

Marquette University

(A comparative Analysis showing the negative and positive correlation between High School Rank, College Grade Point averages and American Council on Education Raw Score Ranks.)

One estimate made concerning the ratio of Engineering freshmen to Engineering graduates suggests that by 1960 approximately seventy thousand freshmen will be needed to supply approximately one-half this amount of graduates. At first glance we might question the enormous gap between the two groups. However, those of us whose assignments quite closely parallel the activities of our freshmen can readily visualize the many unforseen situations appearing with more frequency among our student bodies; thus accounting for the 2:1 ratio between freshman registration and senior graduation respectively. Most of us can visualize quite clearly the reasons for reductions among freshman personnel. We can see, but are we able to understand? As absentism infects our routine, as dropouts occur with more rapidity, and as academic censure seemingly increases with activity among the remaining, ours is a dissatisfied and frustrated lot. Whether our interest lies in Administration or supervision or carries us into the classroom the depreciation in the numbers of freshmen as they proceed toward senior status affects us severely and challenges our very existence as educators. We educate, yet those we would teach are mysterious in their actions and puzzling in reactions to what we would claim as normal situations.

Although we possess at present many standardized forms of human measurement, we are unable to plot and account for human behavior as we would mechanical or electrical energy. Counseling can be dangerous and disasterous at times if performed without skill and an analysis determined without reason. Therefore, that which would be proposed here as a possible solution to a seemingly unsolvable problem must be accepted with the reservation that human behavior cannot be couunted for with infallible accuracy.

Useful Measuring Devices

On the other hand, it would seem unwise to proceed year after year totally unaware of the usefulness of existing educational measuring devices and the tremendous possibilities they afford insofar as Administrative and Counseling functions are concerned.

We are apt to judge the performance of our students as a group rather than as individuals. Assuming, as most of us do, that our freshman registration represents the upper third of our high school enrollment, we measure their progress on the same basis. This hypothesis would suggest that all high schools are of equal size, equal staff, possess the same facilities and offer identical extra curricular activities. If this represented the actual situation we might then assume the upper third of our high school enrollment, which accounts for a high percentage of our

freshmen, to perform with nearly equal results.

We know that many of our freshmen come to us from small schools with poor facilities and staffed unfortunately, but all too frequently, with tired, inefficient and uninterested personnel. Compare the background of these students with those from an entirely opposite situation. Can you in all fairness expect students affected by different environments to possess the same immediate potential? In an analysis of this sort, we are reminded of the students coming to us from the sub-standard scholastic environment mentioned previously who, in many cases, perform with academic zeal. In other words, with careful consideration given to all of these situations, are we justified in our appointment and classification of freshmen according to high school rank?

The first hypothesis to be set down here states that we are not. On the other hand, it would be unwise to seemingly criticize a procedure without proposing a new method to correct the inaccuracies and inefficiencies of the old. As a contribution in this direction it will be shown here how the American Council on Education raw score ranks can be used effectively as Administrative and Counseling aids.

The graphical analysis shown in the illustrations indicate what Marquette University's College of Engineering has done and is still doing to bring to its freshmen effective counseling. We have felt this need much more since the High School graduate has once more become the nucleus of our educational program. More time must be spent and more of our effort expended on those students offering the greatest Engineering potential.

The first analysis was made with a relatively small freshman group numbering 160 students. Although this particular class was larger, test results were not available for all of the students.

Each of the 160 students had been given the American Council on Education test, and his relative raw score rank determined. The A.C.E. raw score ranks were purposely arranged in ascending order as shown in Fig. 1A with student No. 1 representing the lowest and student No. 160 the highest rank.

At the end of each successive quarter, for the following six quarters, a record of each student's academic rank was established and recorded on the graph directly above his A.C.E. raw score rank (Fig. 1B). The purpose of this procedure was to show justification for belief in a correlation between A.C.E. raw score rank and grade point averages. The graphical analysis shown in Figure 1B represents a grade point average over a period of six quarters for each of the 160 students. Graphically, a very high positive correlation is evident between the A.C.E. raw score ranks and grade point averages. The mathematical correlation between grade point averages and the corresponding A.C.E. raw score ranks shown is (.7).

These results indicated the possibility of much success in correlating A.C.E. test results relative to future student counseling.

Correlation

In addition to showing the evidence of an existing correlation between the A.C.E. raw score ranks and college grade point averages the necessity was apparent for proving the hypothesis of the absence of correlation between high school rank and college grades.

Each student's previous high school rank was registered graphically with relation to his college academic average (Fig. 1C). Because of the normally accepted theory relative to a high positive correlation between these two, it seems probable that the graphical solution shown here in Fig. 1C might serve as an illustration indicating the lack of confidence to be placed in the determination of college potential relative to high school performance.

To permit these results to function as

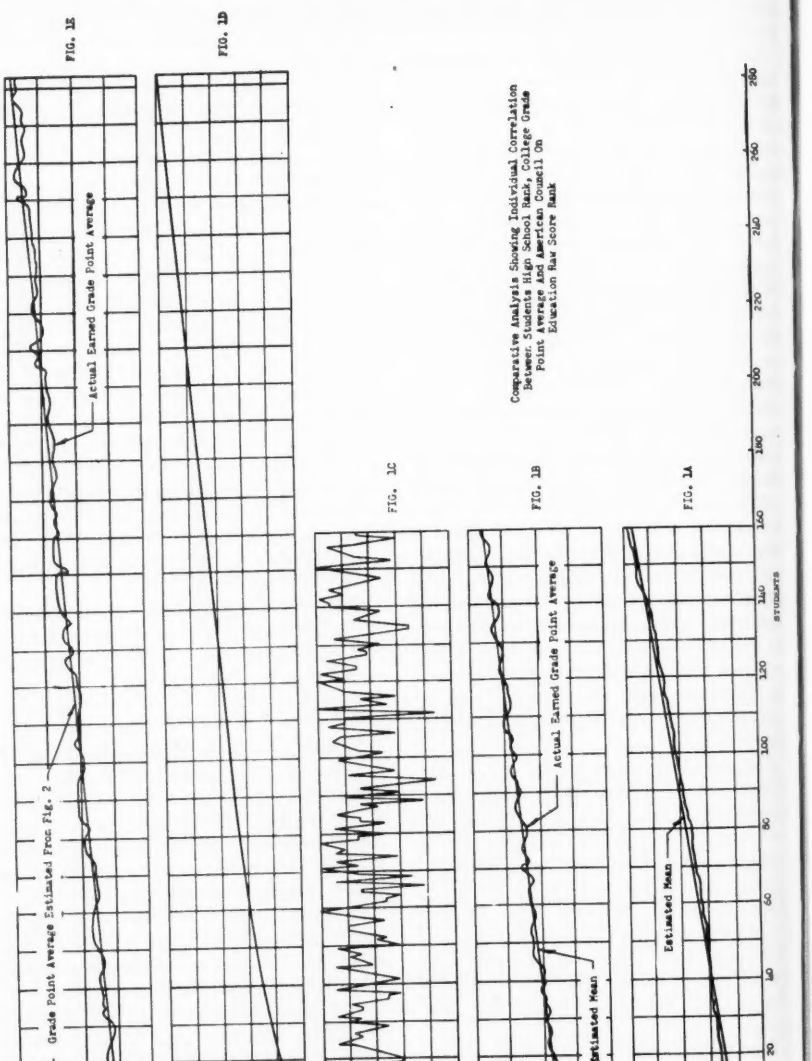
FIG. 1E
Grade Point Average Estimated From Fig. 2
Actual Earned Grade Point Average
Grade Point Average For 1st (3) Quarters
FIG. 1D
A.C.E. Raw Score Rank
FIG. 1C
High School Rank
FIG. 1B
Comparative Analysis Showing Individual Correlation Between Students High School Rank, College Grade Point Average And American Council On Education Raw Score Rank
Actual Earned Grade Point Average
Estimated Mean
Grade Point Average For 1st (6) Quarters
FIG. 1A
Estimated Mean
A.C.E. Raw Score Rank
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an administrative and counseling aid, it was necessary to transfer the graphical solutions into a more positive and functional form. To promote this end, a straight line grade point average was drawn to exclude high and low variations (Fig. 1B). This can be justified on the basis that variations away from this line might be due to a few unreliable A.C.E. test scores or outside influences affecting a student's academic performance.

The straight line representing the mean grade point averages for all cases permitted the determination of an approximate grade point average for each A.C.E. raw score rank. The results of this analysis are being used on an exploratory basis for counseling new applicants and currently enrolled freshmen. The graph shown in Fig. II, having been derived from the foregoing investigation, is now being used for these purposes.

The analysis of Fig. (2) permits a more concentrated counseling effort by separating the group into three distinct divisions, namely: (1) Students from 60 to 99 A.C.E. raw score rank who are to be accepted with the understanding that their status is tentatively probationary. Immediate use of University guidance facilities is recommended for this group. (2) Students from 100 to 119 A.C.E. raw score rank who might actually be designated as the border line group where individual academic rank could very well go in either direction. University guidance facilities are recommended for this group sometime during the first quarter. (3) Students from 120 to 160 A.C.E. raw score rank. Academic censure among this third group will usually be due to outside influences and not lack of ability. Full use of University guidance facilities is recommended for this third group only in extreme cases of academic censure.

Counseling Program

The three divisions as described here should, of course, be used for preliminary investigation and will prove most desirable in laying the ground work for an effective counseling program. However, the appearance of a student in any one of the three classifications must not be treated as a basis for all future counseling until the student's academic performance together with the administration of all available guidance and testing material has shown the classification to be correct.

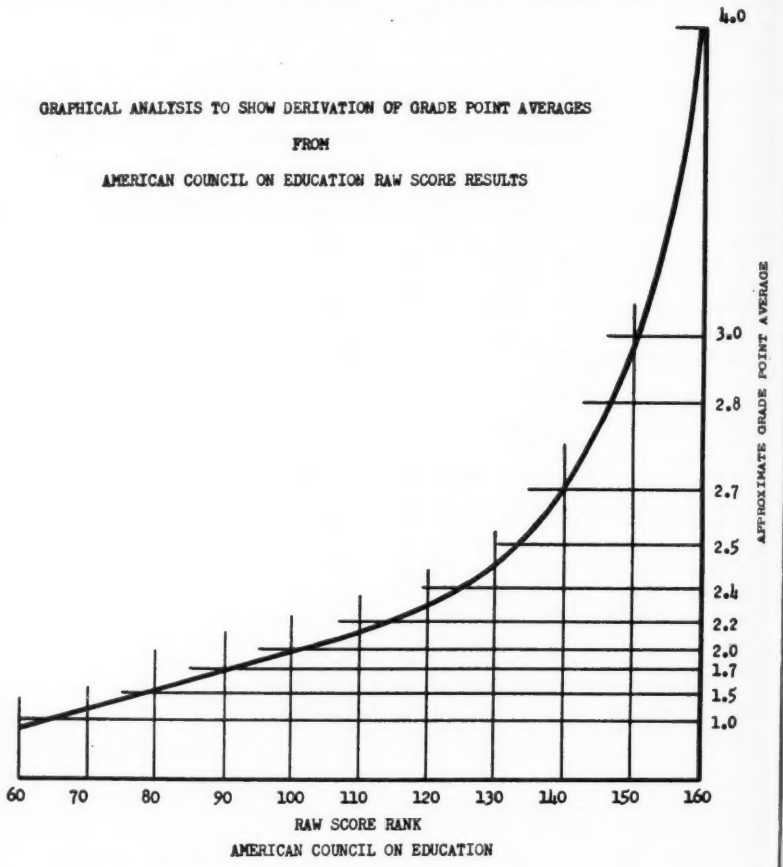
Perhaps the greatest good to be derived from this part of the analysis is the follow-up possible concerning an able student with low academic achievement. Much counseling time has, in many instances, been wasted and not justifiable because of the low academic potential of the counselee and the lack of supporting evidence available to the counselor.

More of our time must be allotted for the derivation of causes of failure among those students possessing the tools for academic success. At the same time, it is a poor policy and indeed a waste of time to push a student beyond his capacity.

An additional follow-up study was made to determine the correlation between the results of the research illustrated in Fig. 2 and the potential grade point averages of entering freshmen. The graphical analysis illustrated in Fig. 1E A.C.E. raw score rank been 97, his estimated and actual earned grade point average.

All of the 284 freshmen represented in this follow-up study were administered the A.C.E. test, Fig. 1D. From these raw scores, a grade point average was assigned based on the analysis in Fig. (2). As an example: Had a student's A.C.E. raw score rang been 97, his estimated grade point average selected from the chart (Fig. 2), would have been approximately 1.9 (C −). In a like manner an estimated grade point average was made for each of the 284 students (Fig. 1E). For three quarters an accurate record was made of each student's academic progress. The graphical analysis shown in Fig. 1E indicates the mean earned

grade point average for each student and its comparison with the estimated average made prior to his participation in the Engineering curricula. The graphical analysis indicates the existence of a high correlation between the two.



60-99 — These students should be accepted with understanding that status is tentatively probationary. Immediate use of University Guidance Center facilities is recommended for this group.

100-119 — This is the border line group where academic rank could go in either direction. Recommend use of University Guidance Center facilities for these students sometime during first quarter.

120-160 — Students in this group should do well. Academic censure in most cases will be due to outside influences and not to lack of ability. Recommend use of Guidance Center facilities in case of academic censure.

FIG. 2

Conclusion

The predetermination of a student's approximate scholastic attainment before his active participation in an educational program, if used wisely by proper administrative personnel, can be beneficial to both the advisor and advisee. However, care must be exercised to eliminate classification of a student's ability in a particular field before performance has shown the analysis to be correct.

The research as presented here is now being carried on with a larger group under most favorable testing conditions to verify, it is hoped, previous results obtained and for the alteration, if necessary, of any data tending to affect the final analysis shown in Fig. 2.

It is felt that the results of this study, as they are being used, will afford greater vision toward the promotion of the academic welfare of each individual engineering student as is now evident by the appearance of new possibilities of research and will in time provide an atmosphere of greater understanding between administrative and student personnel.

Can Technical Institute Graduates Succeed in Engineering Colleges?

By LEO F. SMITH

Dean of Instruction, Rochester Institute of Technology

and

LAURENCE LIPSETT, *Director Counseling Center, Rochester Institute of Technology*

The primary objective of a technical institute is to prepare graduates for a technical job or a cluster of such jobs. A certain percentage of graduates of technical institutes, however, develop an interest in pursuing their education toward the bachelor's degree.

There is very little information available regarding the success of technical institute graduates in entering and completing post-institute education programs. It was the purpose of this study to determine the amount of academic transfer credit received by graduates of technical programs at the Rochester Institute of Technology and to find out the subsequent success of those graduates in the institutions to which they transferred.

It should be pointed out that the R.I.T. programs under consideration were definitely terminal in nature and were not designed to obtain transfer credit.

Procedure

The Department Heads of the ten day-school departments at the Rochester Institute of Technology were asked to submit the names of a sampling of graduates during the last ten years who were believed to have completed programs in four-year institutions. The transcripts of these students were then obtained from the institutions to which they had transferred. There was no direct contact with the students themselves.

Of the total group of students followed up, 31 were graduates of the following three curricula: Electrical Technology, Mechanical Technology and Industrial Chemistry. This sample of 31 students did not include all of the R.I.T. graduates of these three departments who might have transferred to other institutions, but in general these students were among the more able scholastically.

Twenty-two of the 31 students had completed technical institute programs which were full-time during the first school year (38 weeks). During the second and third years the students alternated at ten-week intervals between school and cooperative employment in industry. In other words, these students had completed two full years of academic work in a three-year period. The other nine students in the sample had attended the Institute prior to 1946 when the entire three-year program had been on the cooperative basis. These latter students had, therefore, completed somewhat less than two academic years of classroom work.

Results

1. All 31 students in the sample obtained bachelor's degrees.

2. Twenty-three of the 31 students received degrees in engineering; the remainder received degrees in the physical sciences. (All of the engineering cur-

riculums represented in this study are E.C.P.D. accredited.)

3. The average amount of transfer credit for the 31 students was 61 semester hours, and the range was from 27 to 94 semester hours. (Credits recorded in terms of quarter hours were converted to semester hours.)

4. The grade-point average for the 31 students was 2.82, and the range was from 1.74 to 3.68 (Where A = 4, B = 3, etc.)

5. The amount of transfer credit received and the grade-point averages earned by the graduates of other R.I.T. departments, who transferred to four-year institutions, were at least as high as those received by the graduates of the Electrical Technology, Mechanical Technology and Industrial Chemistry curriculums.

Conclusions

This study is based upon only a sample of the graduates of three technological curriculums at the Rochester Institute of Technology who continued for post-institute education. Although the number of graduates included in the study is not large, the official transcripts of the institutions to which these students transferred make clear two major points:

1. That some engineering colleges grant substantial amounts of transfer credit to qualified technical institute graduates.

2. That this transfer credit is justified in terms of the subsequent success of those transfer students in the engineering colleges.

ANNUAL MEETING

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Pennsylvania State University
State College, Pa.

Arts and Sciences for Engineers

By WILLIAM WHIPPLE, JR., *Colonel, CE, U. S. Army*

Modern business and modern government obviously require the broadest possible understanding of economics, political institutions, labor and public relations, and international affairs. Our country has lost the institutional and fiscal rigidity that once allowed industry to operate within fixed rules on a laissez-faire basis; and almost any business must now have a constant eye to its relationships with government, with labor, and with the public. Competitive strategy of big business in the modern world requires an understanding of national political economics as well as the traditional play of the market. In addition to this, the Federal government, for better or for worse, is engaged in many large scale engineering and scientific enterprises which require the broadest possible national outlook for their proper execution. Finally, within the last six years, both private firms and governmental agencies have become involved in an unprecedented series of engineering and technical activities abroad, bringing larger numbers of Americans into intimate contact with the social and economic affairs, the law and the people of other countries all over the world. If the broader purposes of such missions are to be fulfilled, our representatives abroad must have imagination and insight, in addition to the required technical abilities.

At the same time that engineers and industrialists are being thrown increasingly into situations where they need the training of politicians, economists and diplomats, the technical requirements of the professions are becoming more complex. The proliferation of new developments in the sciences and in chemical and electrical engineering calls for intensified training in the chosen field rather than allowing for breadth of education. The same tendency, though not quite so marked, exists in civil and mechanical engineering. Engineering Societies' statistical analyses of financial compensation have added strongly to such tendencies by showing that recent graduates with Master's degrees in engineering or science have materially higher starting salaries and maintain their advantage thereafter, and that those with Ph.D.'s are still more highly paid. These statistics, while they serve the useful purpose of outlining critical needs for highly trained men, must accentuate the trend toward compartmentalizing the engineer and the scientist into restricted fields, unless the curriculum of graduate study can be broadened in some way.

A marked difference in intellectual viewpoint exists between engineers and liberal arts students, and also between their respective faculties. It is striking to an outsider to note what differences in attitude characterize faculties in (say) engineering, agriculture and political science, and each has its counterpart in the alumni world in which the rest of us live. Chief engineers and attorneys, for example, are apt to have entirely different basic business concepts, although the really qualified executive will often include both. On matters pertaining to governmental affairs, characteristic attitudes and persistent misunderstandings between groups can repeatedly be traced to the academic source. In addition to divergences of viewpoint, there exist important hiatuses in the development of knowledge which have not been covered

adequately by either group. It is widely realized that the very highest concepts of education and of national interest require an intellectual integration of the diverse points of view in the world of today.

Admirable in Concept

The inculcation of a broad philosophical background for leadership through the liberal arts approach is admirable in concept, its main defect being that it does not leave the graduate in an advantageous position from which to enter any particular line of work. The very high proportion of lawyers who attain high policy making positions in Government, for example, does not stem nearly so much from the direct value of the knowledge acquired in the university as from the availability of a career pattern leading to the acquisition of influence, diversity of knowledge, and the habit of solving problems quickly. The finest intellectual background and the soundest of conclusions on important matters may be largely wasted unless they can be applied to affect the lives of other men. In democratic America, leaders are chosen from many elements of society, and it would be fallacious to compartmentalize university education today on any assumption that the engineering graduates will remain in technical fields.

In any enterprise involving applications of engineering science the vast majority of the major problems confronting senior executives require knowledge other than technical for their solution. These aspects become more important and take more of the individual's time the higher he ascends in his career pattern. Prominent among these matters are personnel management, legal aspects, public relations, labor relations, economic and financial relationships, governmental affairs, techniques of negotiating and techniques of self-expression. Mistakes in these fields are as costly as technical mistakes, and abilities in these fields, or at least a number of them, usually characterize the successful executive. It is on account of the engineer's deficiencies in these nontechnical fields that lawyers and bankers often take over the management of enterprises of a technical nature, successfully correcting various deficiencies and overcoming their own lack of engineering knowledge by the simple technique of accepting specialized advice from the proper specialists. The young man who has spent five to seven years acquiring advanced technical education remains very deficient in the background essential to an executive.

In a few colleges with the strength of their convictions, the basic engineering course has been broadened materially. Time for such extra subjects can only be found by leaving out applications and concentrating on basic engineering and mathematics. From a long-term point of view, this is sound; as many current engineering applications, impressive as they now appear, will no doubt be as obsolete in twenty years as the technology of 1933 is today. However, from the point of view of a company or agency looking for new men to do an urgent job, which is the most favorable situation for new graduates, some degree of familiarity with modern technology is a great advantage. In this competitive world, any great degree of broadening the basic engineering curriculum will be extremely difficult for the great majority of colleges to achieve.

Curiously enough, in many high schools the objective of a broad intellectual approach appears to be pursued more enthusiastically than it is in colleges; and immature children are often asked to write a quick theme on such topics as the United States' attitude toward Soviet participation in the United Nations. At such levels of education, interest-stimulating techniques without much basis of factual analysis are all that is practicable. Such indoctrination offers a real advantage, provided the child is preserved from the delusion that a decision may be arrived at in such matters after listening to a brief indoctrination by the teacher

and hastily scanning one or two references.

However, it is at college levels, and afterwards, in the years of early maturity when selectivity begins to determine the leaders of the future, that a sound intellectual broadening of the base must be obtained. After success in a career has been achieved, it is much more difficult. There is little opportunity or time to supplement the education of the lawyer who has ascended the bench or has been elected to Congress, of the industrial magnate who enters a policy-making governmental position, or the scientist who becomes head of a great laboratory. Not only has the individual already passed his most formative years, but his time has become too valuable; there are pressing demands upon him which he cannot deny. Many such individuals have through their own inspired efforts or through fortuitous circumstance of changing positions, especially in wartime, acquired the invaluable broadening of outlook. But why should such an important matter be left so much to chance? Our educational processes should provide more ways for the intellectual integration of thought through university training, instead of concentrating higher education on specialization, while leaving a wide gap between the various cultural and the engineering approaches to intellectual development.

As an aside, the terms "liberal arts" and "arts and sciences" as denoting the non-technical aspect of education are generally considered roughly equivalent. In our modern age, in which the onrush of science and technology threatens to outmode philosophy, it is well to hold fast to the value of literature, history and the ethical concepts upon which our civilization is based. But the term "liberal arts" when considered as excluding engineering and, ostensibly at least, science, sounds like an "ivory tower" concept to the practical man. Surely, prominent among the points of view which should be comprehended by a broad cultural approach for instruction of future leaders, the scientific and engineering attitudes and concepts should be prominent. The awkward term "arts and sciences" may or may not be more comprehensive of what the modern scholar should know, but it is certainly more comprehensive of what the modern statesman should know.

Tendency Toward Specialization

The progress of science many generations since has passed the point where any man could be successfully educated as a scientist without specialization. For the future, science will be increasingly specialized, such broad subdivisions as chemistry having in turn been subdivided already into fields in each of which progress is so great that a man must narrow his field in order to master the subject. What the public broadly considers as scientists includes categories of nuclear physicists, chemists, astronomers, and many others, who have widely differing fields. Engineering is subject to the same tendency although to a lesser degree. There are wide opportunities for civil and industrial engineers who have a sufficiently wide technical education and background to integrate the activities of a variety of specialists in the fields of mechanical, electrical and chemical engineering, as well as the simpler structural foundations and materials techniques which they must apply directly. The basic engineering degree in many cases still constitutes a relatively broad education in basic science and in a few cases has been further broadened considerably into non-technical fields, as mentioned earlier, although it has not been possible even in those few cases to approximate the education of "engineering generalists."

A Master's degree in engineering may include certain non-engineering matters such as engineering economics and business law, but is still primarily technical. The doctorate is more apt to point towards specialization; and does not satisfy the need of integration of technical with over-all intellectual concepts. Moreover,

a doctorate in engineering probably represents a longer period of technical education than is either required or desirable for one who desires executive positions in construction or industrial activities. A young man with basic engineering education is more apt to broaden his viewpoint through variegated business experience than through two or three more years of graduate engineering education, valuable though the latter may be for purposes of research or other special technical activities.

In attempting to broaden engineering education, it must not be forgotten that for the future engineer or business man, the first and indispensable requirement is the basic technical background to obtain and to hold a job. Despite recent recognition of the value of a general education on the part of a few top industrialists, there is no use in diluting a technical education to a degree that will jeopardize this primary mission. Most of the engineering graduates in the majority of colleges and universities are going to pursue careers such that their technical proficiency will remain not only initially, but permanently the most important part of their background from the point of view of remuneration and advancement. The problem is to consider how, within these limitations, the objectives we have been discussing can best be achieved. The basic undergraduate training for engineers can only be broadened at the expense of curtailing or eliminating technical subjects. As indicated previously, the engineering applications rather than basic studies should be curtailed. A considerable change in this direction can be made without adverse effect upon immediate job prospects if the student will get a job during the summer, in some practical engineering work. The value of such an internship to the prospective employer is very great. Time made available in this way should allow the instruction of young engineers in a limited number of non-technical subjects, giving them an intellectual background which, while not immediately of value in the first permanent employment, makes them much better prospects for wider leadership in the future.

The extent to which liberal arts subjects should be introduced into an engineering curriculum depends upon the objective. Undergraduates with the greater possibilities of future leadership should be given more non-technical work. Public speaking and good composition and technical writing should be developed to a greater degree incidental to other courses. Literature, philosophy, public affairs and American history courses should be included if possible. A seminar course in the senior year might well be organized jointly with public administration majors, to consider government participation in engineering enterprises. There is ample material which would be stimulating to both groups of students.

In order to make room for such training, some subjects must be combined or reduced in scope, such as water supply, sewage and highways, heating, air conditioning, refrigeration, advanced communication circuits and industrial electronics. Some of this type background can be covered during summer employment or field trips, and in general such subjects can be more readily acquired later when needed than can the more basic engineering subjects.

Change in Educational Approach

Such a change in educational approach will require cooperation from business and governmental employers. In the first place, the employer must accept such graduates with a minimum of theoretical training in technological applications, relying on later job training and experience to give proficiency in productive techniques. In view of the long-term advantages of the system, it is believed this limitation will be accepted, as applied to graduates from colleges of good general reputation, who are being recruited for future assistant executives rather than technical specialists. Most

businesses would just as soon do their own specific job training along their own lines and would willingly accept a summer of previous practical experience in place of a few academic engineering courses, many of which may not be directly applicable to the work at hand.

In addition to summer jobs of an engineering nature for students, arrangements should be made, where possible, for a full year of employment before a graduate year. Such an arrangement will be more difficult to effect, on account of fear by the employer that the well-qualified graduate, after his year on the job and year of post graduate training, would then transfer to some other company rather than return. However, such an interval of work prior to completing graduate work is extremely beneficial, because it gives the subject matter a concrete reality in the mind of the student and a motivating interest that only rarely will be developed from a purely academic approach.

A further advance in effectiveness of education in preparing for leadership could be achieved if the individual could return later, after five to ten years of experience, for a full year, primarily non-technical in nature. Courses would include economics, public affairs, international relations, business administration and public speaking. The selection for such a course would be made after the individual had established satisfactory and stable job tenure and after he was known to be executive material, but not yet a key executive. The award of an academic degree would be desirable though not essential.

Only the interest of top management and a strongly supported system of scholarships could institute such a course on a wide scale. By this period in his life, the individual will ordinarily have started a family but will not yet have achieved financial security or savings sufficient to undertake another year of education at his own expense. The temptation is for management to agree to an additional year only if it relates directly to techniques of the immediately foreseeable future, whereas the more general background would undoubtedly pay higher dividends in the long run, especially from the point of view of public interest.

Conclusion

Such a system as above described, with four years broadened undergraduate engineering study, a year of actual work, and a year of graduate engineering study, followed by a sixth year of more general nature some years later, would be of great advantage in training broader gauge leaders and executives for business and government. It would capitalize heavily on the lost opportunities which result from the intellectual hiatus between the technical and the liberal arts point of view, and from the misunderstandings between operating elements and fiscal or legal advisors of many organizations, and between the engineering and the broader economic and public relations requirements of business. It would provide material for executive appointments in government, making less frequent the harrowing necessity of choosing between the practical man whose ideas and philosophy are closely bound to his own experience and the broad thinker and analyst whose basically valid ideas cannot be implemented within the bounds of practicality.

CANDID COMMENTS

An Open Letter to Industrial Executives

By R. D. LANDON

Dean, College of Engineering, The University of Akron

Mr. U. R. Entrepreneur, President
Expando Corporation

Dear Sir,

During the last few years in particular, we have appreciated the increased interest which your company has demonstrated in the engineering graduates from this college. We have welcomed your interviewers to our campus, supplied them with convenient facilities and furnished them with complete information on students in which they have been interested. We have been gratified that your company has selected a number of our graduates for technical employment in your organization. We have gained satisfaction from your reports that our graduates are measuring up to their responsibilities. We trust your interest will continue and that we shall always be able to produce graduates which will meet your rigorous specifications for young engineering talent.

There is no assurance, however, that we can continue to produce graduates of this same caliber. We, along with so many other colleges which are forced to operate on a relatively fixed income, are not presently in a financial position to compete with industry for the services of outstanding graduates. Some graduates whose first interest is in teaching are willing to accept a small differential in salary but they will not accept an essentially lower standard of living, nor should they be expected to, in order to follow the teaching profession. It is most difficult, therefore, for many engineering colleges to recruit the proper caliber of young teachers who should become the core of our faculties in future years.

Another serious difficulty in building a competent and stable staff stems from the practice of some companies which are offering every possible financial inducement for our most promising young instructors to leave their educational work and accept industrial employment. As a matter of record, your company has just offered one of our outstanding young instructors a salary as high as we can afford to offer a full professor. Consequently, many engineering colleges are now faced with the dual difficulty of *recruiting and holding* promising young teachers.

We fully realize that industry needs the best young talent it can recruit and we know that the competition between some companies, and even between divisions of the same company, to secure the services of promising engineering graduates is very keen. Since, in this competition, the colleges are being forced out as active competitors, is it not evident that industry will be the ultimate loser? How can competent graduates be produced if there is not a high degree of competency with stability in our college faculties and how can the colleges insure this competency and stability if they are in an unfavorable position to bid on the open market? These are questions which we must ask industry to help us answer since they cannot be answered with the resources available on many college campuses today.

We have watched with keen interest the development of your scholarship program which is making it financially possible for more and more highly qualified high school graduates to prepare themselves for technical employment in industry. To use your terminology, the scheduling of selected basic material to the engineering schools is improving but the processing is becoming more difficult as our manpower resources are being siphoned off.

Can you afford the risk of not insuring the quality of instruction your young engineering employees should receive? Is it possible, therefore, that you would be able to provide financial assistance to the promising young *instructor* as well as to the highly qualified young *student*?

We are calling this problem to your attention now because we believe you will appreciate that it is ultimately yours as well as ours. Unintentionally, industry helped to create it and now we need the benefit of your experienced judgment which, together with your material aid, could be major factors in the solution.

We trust that your interest will promote a cooperative effort, the results of which will benefit both engineering education and industry.

Very truly yours,

A. N. EDUCATOR, *Dean*

Teaching Tips

Leadership Training in the Laboratory

By WALTER E. ROGERS

Associate Professor of Electrical Engineering, University of Washington

If I were trying to promote a wider readership of this article, I should perhaps entitle it: "How to get out of the laboratory at 5 o'clock." In fact I was answering this very question recently, when I realized that deliberate and planned training in leadership and organization was not the wide spread practice that I had assumed it was. I grew up with this system about 20 years ago in the mechanical engineering laboratories at the University of California, so I cannot claim to be more than an advocate of the system. Of these undergraduate days, few details are now distinct, but I remember the leading and planning of experiments very clearly, and I expect that almost everyone who has experienced this teaching method at the receiving end was similarly impressed.

The idea is a very simple one. Warned in advance, one member of a laboratory party is made completely responsible for the conduct of an experiment. He is required to list the equipment which will be needed, including such details as the ranges of the instruments. He makes his own abbreviated step by step procedure from a study of the syllabus sheet or the general requirements outlined by the instructor to the class, and facilitates the assembly of the apparatus by preparing circuit diagrams. He assigns the various tasks of the day to the other members of his party. He may delegate such details as seem fitting, such as instrument calibrations, preliminary warm-ups, roughing out the data sheets, and providing the carbon paper. He retains responsibility for the dispatch and the efficiency of the conduct of the experiment. Required to submit and discuss his plans with the instructor in advance of the laboratory period, the leader frequently finds ways to suggest additional lines of investigation somewhat beyond the call of duty as outlined on the syllabus sheet.

The right and proper objection to all this, is that each and every student should plan every experiment he performs, understanding its goal rather thoroughly before he arrives at the laboratory. This ideal is as difficult to attain as is the corresponding utopia in which every student studies his lesson every day. On the other hand, rotating this responsibility from man to man throughout the course seems to encourage planning on the part of the rest of the party. For one thing, the students are keenly aware of the possibility that the leader may not show up. Further, they soon find out that the best planning is done when the entire party gets together and all contribute ideas.

It is a pleasure, pardonable I think, to observe the ingenious punishment which can be conceived by a group of students for the lackadaisical leader. Recently one of these arrived at the appointed hour, just before the laboratory period, having read the syllabus, but without having prepared written plans

and diagrams. According to the rules, no power could be applied to the circuits until the leader had met the requirements. While this boy was thus occupied, his partners, having also planned in advance, wired up the equipment in a weird and wonderful way. Most of the changes required in going from one test to another were to be accomplished by an elaborate array of switches rather than by rewiring. This made an imposing circuit to check.

The errant leader, meanwhile, had drawn his circuits in the conventional manner doing one thing at a time. After approving his belated plans, we walked together to his test section, and thinking I saw a gleam in the eyes of one of his partners, I asked the leader to explain to me just what this patch board was intended to accomplish, and how he proposed to operate it. In particular, which switch was he going to open if unexpected difficulties arose? Of course, he had little idea of what was being done to him, and his partners were of no help at all. About half an hour later he had figured things out, and after explaining them to me, handled the rest of the afternoon's proceedings rather well.

Getting the students' cooperation on this is easy. It may be set up simply as a rule of the course, or it may be sold the first day with a practical story from industry. I describe the economics problem behind the crews of riggers, electricians, machinists, and the like which are required to set up and test a piece of machinery. One can also point out that if the engineer directing the test discovers the next day that he doesn't have all the data he needs, he may find that the machine is now in a box car and half way to the customer.

From the educational standpoint, I think this sort of thing carries what could be a more or less routine laboratory assignment a little closer to the project method of teaching that we hear so much about, but sometimes find difficult to apply in courses which we teach only infrequently.

Getting back to the 5 o'clock question, it is really surprising what a group of students can accomplish in a 3 or 4 hour period when they know what they are going to do, and are working under a time limit.

A Comprehensive Testing Method for Advanced Courses

By W. W. TURNER

Assistant Professor of Electrical Engineering, University of Maine

A difficulty with many types of examinations given in engineering courses is that they test the ability of the student to apply theory to a particular problem solution without determining whether or not he understands the physical significance of the results obtained or if he can draw general conclusions from particular results. Since these last two qualifications are important in the practice of engineering it seems desirable to at least get an indication of the extent to which they have been developed in the individual student and in so doing to impress on him their importance. The testing method herein described provides a means of measuring these abilities and at the same time demonstrates the effect of varying a particular system parameter without requiring each student to repeatedly perform the same calculation using different numerical values. It also shows the advantage of a team approach to a problem as well as giving the student an opportunity to work independently on a fairly involved problem.

The technique outlined below has been successfully used by the author in a second semester senior course in feedback control, but should lend itself to other courses in which system performance is the major consideration.

1. Design a problem in which the effect of varying certain parameters is to be determined and assign each student particular values of parameters for which he is to determine the system response. In feedback control the problem might take the form of finding the changes in resonant frequency and allowable gain for a specified maximum ratio of output to input as the time constant of an RC integrating network is varied.

2. Encourage the students to compare their methods and results in order to discover for themselves the general effect of the variations and to see if their results are reasonable when compared with those for other parameter values.

3. A few days before the examination is to be given collect the solutions and tabulate the results, inserting additional values, some of which are incorrect.

4. Return the solutions with corrections and comments not only on the final answer but also on the methods and techniques employed.

5. Ask questions on the examination which can be answered only if the student understands the methods he has used and has been diligent in making his comparisons with the other solutions. Typical questions might be (a) analyze the tabulated data to determine if any results seem inconsistent and explain why they appear to be out of line, or (b) discuss the effect of changing some other parameters in the system. In the feedback control problem already cited one might ask the student to determine the effect of changing the resistance in series with a generator field winding. (This simply changes one of the other time constants of the system and therefore its effect is predictable from the data already obtained.)

Since the validity of the conclusions is to be emphasized rather than speed, the number of questions should be kept to a minimum in order that the student can give careful thought to each one. Grading of this type of examination might be accomplished by assigning a minimum passing grade for the satisfactory completion of the problem and letting the answers to the examination questions determine the A, B, and C students.

Use of this method with small groups of less than ten has indicated that the students like it because the emphasis is on quality of the work and not on speed. Resulting grades appear to be more representative of engineering ability than those obtained from some other types of examinations. There would seem to be no obstacle to applying this testing procedure to larger groups except that in general it probably demands more of the instructor's time to do a careful job of grading than would an examination requiring only numerical answers.

Personalizing Teacher Student Relations by the Use of Student Pictures

Professors who find it difficult to learn the names of their students when they are each semester confronted by one hundred or more new faces may find some help in a method that Professor Lawson has successfully used to solve this problem. Several years ago at the University of Florida he decided to do something about his own situation and started taking group pictures of each of his classes. He then had these pictures enlarged, cut out the individual pictures,

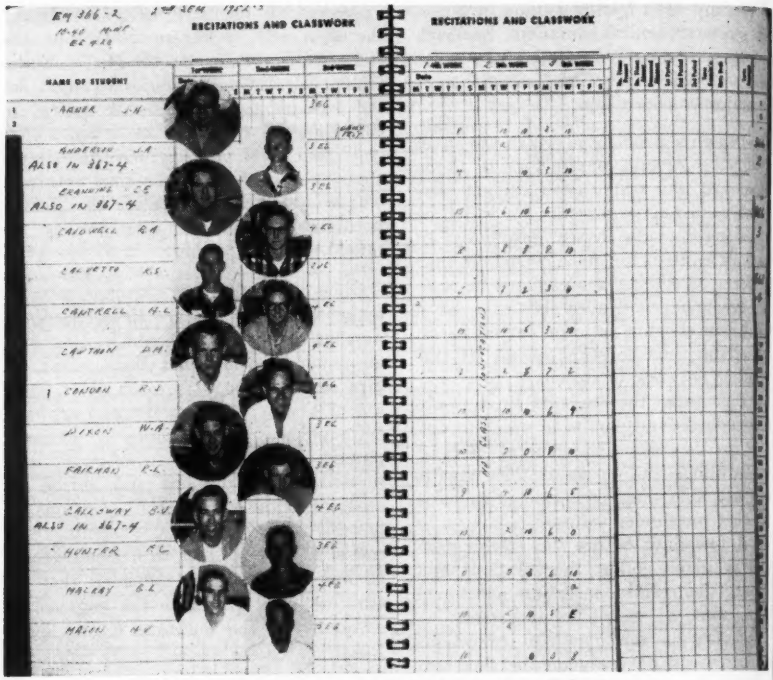

FIG. 1. Individual student pictures in roll book.

MILLER, R.

Semester	Course	Grade	Remarks
1st 1950-51	EM 365	E	Poor math preparation - Worked hard
2nd 1950-51	EM 365	B	
1st 1951-52	EM 367	A	
Summer 1952	EM 366		Dropped course - Carrying too heavy load
1st 1952-53	EM 366	B	
			Neat steady worker - Would like to
			have him as an employee.

FIG. 2. Individual permanent student record card.

and attached them opposite each name in his roll book as shown in Figure 1.

He found that this method helped in getting to know his students quickly. However, there were disadvantages to the group pictures because of absences or latecomers to the course. This semester Professor Lawson set up lights and a 35 mm camera in his office and used the last ten minutes of the first day of each class to take individual pictures of each student. Twenty-five pictures can be taken easily in five minutes or less. With the camera at about four feet from the subject, contact prints can be used, and at least twenty-five pictures can be printed on each sheet of paper. The cost is negligible. The camera can be left set up to get any absentees or adds.

Professor Lawson makes further use of these pictures by keeping them in a permanent card record. He has duplicate prints made of the pictures and puts one copy on a mimeographed card as shown in Figure 2.

This card file has proved invaluable when called upon for recommendations for students whom the professor hasn't seen for several years and whose face he cannot recall.

Dartmouth's "Shop" Course

By J. J. ERMENC, *Professor of Mechanical Engineering* and J. A. BROWNING, *Assistant Prof. of Mechanical Engineering*

The molding of the Shop Course at Dartmouth was influenced by those thought-streams in engineering education which suggest that

1) The conventional shop course in engineering colleges is a manual training course, and, in toto, represents a sub-minimal achievement;
2) Tests or experiments can be performed in college shops which can be as intellectually significant as those performed in those laboratories liaisoned with such courses as Fluid Mechanics or Thermodynamics.

The course, started in 1949, is given during a five-week period immediately preceding the fall semester of the fourth year of the five year curriculum. The week consists of five eight-hour days.

About two weeks are used for the usual shop work and welding. (Pattern-making, foundry practice, forging and the like, are dealt with "sotto voce." The general picture of these aspects of shop are presented via movies followed by an occasional lecturer who may speak on some scientific aspect of the subject.) Some simple but ornamental piece is made in the shop to involve the use of the fundamental machine tools. A few days are allotted to the acquiring of sufficient skill to make butt and lap joints with both gas and electric welding. A fillip to the welding session is the tensile testing of student work.

The remaining three weeks of the term is used for the experimental or test work. Three days are devoted to each experiment, split more or less evenly between the gathering of data and the supervised writing of a formal report. The experiments or tests performed are concerned with:

1) The performance of a milling machine;
2) Metal-turning principles;
3) An introduction into the machineability of steels;
4) Spot welding principles.

The milling machine test relates power per volume rate of metal removed to

speed, feed, and depth of cut as well as the characteristics of the cutting tool and the material being cut.

By means of a Lando Autographic Dynamometer, the effect of lathe tool angles on cutting forces are easily determined as well as the power requirements for variations in speed, feed, depth of cut, and materials used.

The determination of the machineability of steels by a drill-penetration method attempts to correlate this factor with the physical properties of the steel.

The test using the spot welder is an investigation into the time variables of squeeze, weld, and hold, as well as weld pressure, current, materials, and surface oxides on the strength of welds.

The speed with which students finish their manual training varies considerably. This slack is taken up by the design and construction of some simple device. The most ambitious project has been the design and construction of a milling machine dynamometer. The usual product falls in the personal gimmick category.

There are excellent movies available on fundamental shop practices which are used and a visit is made to a nearby foundry and machine tool manufacturer.

The course in its experimental aspects provides an intellectual stimulus to the student as well as the instructor. It is a growing asset to the mechanical engineering curriculum.

THE T-SQUARE PAGE

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Graphics Conferences

By J. NORMAN ARNOLD
Associate Professor of General Engineering, Purdue University

Two conferences on "Graphics" which were held during the fall of 1953 carried forward the objectives of the Advanced Graphics Committee of the Drawing Division even though the conferences were sponsored by Midwestern universities and industries rather than by the Division.

One called an Engineering Institute on "Graphical Presentations" was held at the University of Wisconsin on October 6, 7, and 8. Those registered for the Institute included engineers employed in a variety of industries mostly from Wisconsin and Illinois.

The topics discussed during the three-day session included: General Methods for the Solution of Functions of Two or More Variables, Uses of Graphs, Conic Sections and Power Functions, Empirical Equations from Engineering Data, Analogue Computer Demonstration, Network Charts, The Graph Analogue, Graphical Calculus, Special Slide Rules, Alignment Charts.

The discussion leaders represented several University of Wisconsin departments and also included one representative each from Northwestern University, Purdue University, and Gerber Scientific Instrument Company.

A feature of the closing session of the conference was the presentation of particular problems to the discussion leaders for their comments and suggested methods of solution.

The second, or "Engineering Graphics Conference," was held at Purdue University on November 20. Engineers from Indiana and neighboring states as well as several college representatives attended.

The topics discussed included: Introduction to Graphics, Delineation, Analogous Representation, Problem Solutions, Computing Devices, and Reproduction Processes. The speakers on these topics were Purdue University staff members, with discussion by industrial representatives. The program was planned by a joint University-industry committee.

A feature of considerable interest was an Engineering Graphics Exhibit open to the public, and particularly convenient for students to see, throughout the week including the conference day.

Conferences like these provide an excellent opportunity for engineering drawing teachers to learn of developments in industry and for practicing engineers to become better acquainted with some graphical devices and methods. The acquaintanceship which is stimulated and the discussion of some problems of mutual concern are beneficial all round. It

seems possible that conferences like these might aid engineering drawing departments to meet the challenge of the times.

The Wisconsin conference was conducted by Professor Paul J. Grogan for the College of Engineering and University Extension Division.

The Purdue conference was sponsored by the Department of General Engineering in cooperation with the Division of Adult Education. Professor J. Howard Porsch served as chairman.

Proceedings have been published as a Purdue Engineering Extension Bulletin.

Teaching Positions Available

The following rules were adopted by the General Council of the ASEE:

The privilege of advertising for teaching positions is extended only to colleges and technical institutes which are either Active or Affiliate Institutional Members of the ASEE. Advertisements must be for positions available only. No advertisements will be accepted for an individual seeking a job.

Advertisements must be submitted not later than the first day of the month preceding the month of issue. Because of limited staff, the ASEE headquarters cannot maintain personnel files or supply detailed information about jobs. In replying to blind ads, address letters to American Society for Engineering Education, Northwestern University, Evanston, Illinois and give blind ad number. Information and rates for advertising in the Journal can be received by writing ASEE Headquarters. In order to conserve space and achieve uniformity, the privilege is reserved to rearrange advertisements.

INSTRUCTORS (2) IN MECHANICAL Engineering, to teach kienmatics, machine design and related subjects. Opportunities for sponsored research. Large university in Middle Atlantic region. MA–1.

INSTRUCTOR OR GRADUATE ASSISTant in petroleum production engineering beginning September 1954. Opportunity for graduate work toward M.S. degree. Apply to Petroleum Engineering Department, 105 State Hall, University of Pittsburgh, Pittsburgh 13, Pennsylvania.

ASSISTANT PROFESSORS (2) OF ELECtrical Engineering. University of North Dakota, Grand Forks, No. Dak. Duties: One man to teach electronic and communication courses, and one man to teach electrical power courses to undergraduate students. Appointments to begin in September 1954. An advanced degree plus some teaching or industrial experience preferred. Submit resume of education and experience to Head, Electrical Engineering Department.

INSTRUCTOR OR ASSISTANT PROFESsor of Electrical Engineering; M.S. desired with specialization in electronics; to teach communications, circuits, and radio wave propagation courses. Also, Instructor or Assistant Professor of Mechanical Engineering, M.S. desired with leanings toward heat power, heating, ventilating and air conditioning; or internal combustion engines. Positions available September 1954. Send application to President, South Dakota School of Mines and Technology, Rapid City, South Dakota.

ASSISTANT PROFESSOR OF MECHANIcal Engineering to teach machine design. Must be graduate of an accredited engineering college with some experience, and be familiar with stress analysis, materials and processes, ease of manufacture, maintenance and cost. Salary $4,000 to $5,000 per year for nine months. California. Permanent. J–2.

INSTRUCTOR IN MECHANICAL ENGINEERING. Recent graduate to teach courses in engineering drawing, mechanical engineering laboratory, etc., beginning September 1954. Also an instructor in physical metallurgy and metals processing. Opportunity for graduate study. Good pay and fringe benefits. Location: New England. J–1.

MECHANICAL ENGINEERING GRADUate up to 38, advanced degree preferred, to teach heat engines and related subjects. Salary and rank depend upon qualifications. New building and equipment. Start September 1, 1954. Apply to the Dean of the School of Engineering, University of Mississippi, University, Mississippi.

VIRGINIA POLYTECHNIC INSTITUTE. Instructor to teach Engineering Drawing and Descriptive Geometry beginning September 1954. Must be a graduate in a major engineering curriculum. Experience desirable, but not essential. Apply to Department of Graphics, Building 362, Blacksburg, Virginia.

INSTRUCTOR IN GENERAL ENGINeering, to teach engineering drawing, descriptive geometry and other subjects. Engineering degree required. Appointment to begin Sept. 1, 1954. For further information write R. P. Hoelscher, Room 200 Transportation Building, University of Illinois, Urbana, Illinois.

Minutes of Executive Board Meeting

A meeting of the Executive Board of the American Society for Engineering Education was held on April 9, 1954 at the Missouri School of Mines, Rolla, Missouri. Those present were: L. E. Grinter, *President;* W. L. Everitt, B. R. Teare, Jr., E. A. Walker, W. C. White, *Vice Presidents;* A. B. Bronwell, *Secretary;* G. W. Farnham, *Treasurer.*

Report of the Secretary

1. The Secretary reported that as a consequence of the YET Membership Campaign 400 of the 650 new members were in the ranks of instructor and assistant professor. The Executive Board requested that its appreciation for this successful undertaking be conveyed to the Chairman of YET.

2. The Secretary reported that the General Council had voted 47–0 in favor of adopting the Amendment to By-Law IV, relating to dues of individual members.

Quarterly Financial Report

The Quarterly Financial Report indicated that the deficit for the year may be of the order of $2,000 rather than $4,300 as budgeted.

Investment of Society Funds

The investment of Society funds was discussed. The Society has $69,300 in a checking account which does not draw interest. Of this amount $30,000 was a contribution by the Carnegie Corporation for the Humanistic-Social project, $5,600 is the balance of contributed funds for the project Evaluation of Engineering Education, and $6,000 is contributed funds for the Teaching Aids project. Thus, $41,600 of the cash account represents contributed money, held for special projects. Dean Dawson, Chairman of the Society's Committee on Financial Policy, recommended investment of $5,000 in a savings account and $10,000 in Series K United States bonds. Dean Dougherty, another member of the Committee, had suggested investment in 2½% coupon, negotiable federal bonds.

It was pointed out that some of the Savings and Loan corporations pay between 3% and 5% interest and that funds are insured up to $10,000 by the F.D.I.C. The Board suggested that $15,000 be transferred from the checking account to a savings account in a good conservative bank. It was further recommended that $10,000 be retained in the checking account and that the balance be invested in Savings and Loan Banks, the amount in any one bank not to exceed $10,000. The Secretary will correspond with Dean Dawson to get his views on this matter before proceeding further. Mr. Farnham will get information on Savings and Loan Associations.

Budget for 1954–55

A tentative budget for 1954–55 was presented for consideration. The Board recommended certain changes in budgeted expense and deferred adoption until the meeting in June.

The Board recommended appointment of a committee consisting of Deans Everitt and Teare to study Secretarial salaries.

Annual Meeting Plans

The Board discussed plans for the Annual Meeting. The Secretary and Assistant Secretary have held several meetings with the Local Committee at the University of Illinois. The plans are shaping up for an excellent meeting.

Summer School Financing

The Secretary pointed out that the Society has no provision for financial assistance to ASEE sponsored Summer Schools. They are permitted to charge a registration fee, but this places the financing on a precarious basis since the advance reservation is not known early enough to make definite plans. After consideration of this and other Summer School problems, the Board voted to set aside in future years a reserve of $1,000 to $2,000 to underwrite Summer School expenses. It was understood that the Divisions would endeavor to place Summer Schools on a self-financing basis, but the funds would be available in the event that a deficit occurred. It was also recommended that any excess of income over expense in Summer School operations be returned to the Society to be placed in the reserve pool.

Fall Meetings of ECAC–ECRC

The desirability of holding a Fall Meeting of ECAC–ECRC was discussed. Owing to the substantial proliferation of meetings and the increasing burden on the travel expense budgets of engineering colleges, the Executive Board recommended that ASEE should not hold a Fall Meeting, unless something should develop to specifically warrant it. The General Council meeting will be in conjunction with the ECPD meeting in Cincinnati on October 27, 1954.

Evaluation of Engineering Education

President Grinter reported that the Interim Report of the project Evaluation of Engineering Education had been completed by a small writing committee which met at Raleigh, N. C. This will be sent to all members of the Committee on Evaluation for their criticisms and approval. The next meeting of the entire Committee will be on Sunday preceding the Annual Meeting at the University of Illinois, unless the criticisms indicate need for a full Committee meeting before June. The Interim Report will be available to all those who register for the Annual Meeting and it will be published in the September 1954 issue of the JOURNAL.

The Executive Board recommended continuation of the Evaluation Committee as and *ad hoc* committee. After one year, a Final Report should be prepared, unless greater delay is necessitated by unforeseeable conditions.

President Grinter recommended that the Institutional Committees prepare a revision of their institutional reports in the light of the recommendations of the Interim Report. These would be prepared in sufficient quantity so that they can be bound and made available to engineering college libraries throughout the country.

The Tuesday morning General Session at the Annual Meeting will feature a talk by President Grinter on Evaluation followed by a panel discussion and discussion from the floor.

Resolution to ECPD and Engineering Foundation

The Executive Board voted to transmit the following resolution to ECPD and its constituent societies:

"The members of the Executive Board of ASEE wish to express to the constituent societies of ECPD their grateful appreciation for their financial contribution to the project Evaluation of Engineering Education. This project, which has had the active participation of over 1500 engineering educators throughout the country, has been one of the most thorough studies of engineering education ever undertaken. The project, which was made possible by the contributions of the constituent societies of ECPD and other organizations, has pointed the way to significant changes in engineering education to meet the needs of rapidly developing science and technology; it has engendered a spirit of challenging inquiry which will help to keep engineering education responsive to the needs of the profession."

The Executive Board also voted that a similar resolution be transmitted to the Engineering Foundation.

Investigation of Graduate Study

The proposal of the Graduate Studies Division to conduct a comprehensive investigation of curricular goals of graduate level education was discussed. Professor Christensen, Chairman of the Division, has invited a number of leading educators and administrators in graduate fields to attend the luncheon at which the proposal will be discussed. Several sources of possible funds for the project were considered. The Board recommended that the Graduate Studies Division formulate a specific proposal and prepare a statement of its budget needs so that the Executive Board can assist in the solicitation of funds.

Humanistic-Social Project

Vice President White reported that conferences between Dr. Burdell and Dr. Gullette had been successful in shaping up the initial stages of the Humanistic-Social Research project and that field visits would be made soon. The project will be officially launched in June at the Annual Meeting. An Interim Report will be prepared for June 1955. A printed announcement of the project will be mailed to deans and officers of the Society.

Industrial Fellowships

The Secretary presented a proposal for ASEE administration of a Fellowship program to be financed by contributions from industry. This proposal was developed as a consequence of inquiries which have come to members of the Board as to whether or not ASEE could handle such Fellowships. A number of industries would like to contribute to higher education, but they have no satisfactory formula for making contributions without showing partiality. A Fellowship program, administered by ASEE, in which industrial financed Fellowships would be awarded to recipients selected by ASEE, would provide a means whereby industry could contribute to higher education on an impartial basis.

It was pointed out that industrially financed Fellowships would not contribute substantially to the funds available for engineering colleges, since the cost of graduate level education usually exceeds the amount of income received from the student. The Board recommended that this plan be studied by ECAC.

EJC Proposals on Individual Membership and Regional Membership

Proposals of EJC to develop a plan of Individual Membership, as well as a plan of Regional Memberships, was discussed. Considerable concern was expressed over the proposal to provide Individual Memberships in EJC. The primary function of EJC is to have committees of leading engineers study national problems bearing upon engineering. This type of operation can be severely impeded by an organization containing a large number of individual members, since there would inevitably arise the demand that the individual members be given a vote on important committee proposals. If individual members are denied the privilege of participation, their membership would be meaningless.

No specific action was taken on the proposed amendments to the EJC Constitution, but the Board expressed the viewpoint that the plan for individual membership in EJC does not seem to have been developed to the point where the Society can feel confident that it will make a significant contribution. This matter will be referred to the General Council for consideration in June.

EUSEC Representative

The Secretary reported that ECPD has voted to appoint all three delegates to the EUSEC Conference on Engineering Education, to be held in Switzerland in the fall of 1954, and pay their travel expenses. It was pointed out that ASEE can make a significant contribution to this conference in presenting the Report of its Committee on Evaluation of Engineering Education. The ECPD has invited Col. L. F. Grant (President of ECPD), T. Saville, and L. E. Grinter to serve as representatives.

An industrial man will also be appointed to the commission provided that his company pays the travel expenses.

Printing Costs

The Treasurer presented a preliminary study of the costs of printing the JOURNAL OF ENGINEERING EDUCATION and *Proceedings,* using the offset printing process. This study indicates a possible saving of several thousand dollars per year on the *Yearbook,* but no substantial savings on individual issues of the JOURNAL. It was pointed out that Lancaster Press now provides a substantial service in handling the Society mailing, in storing and selling back issues of the *Proceedings,* and in performing other useful services to the Society. The Treasurer will try to complete the study and present a report at the June meeting of the Executive Board and General Council.

Associate Institutional Memberships

The Executive Board voted Associate Institutional Membership to the following companies:

McGraw Electric Company
Portland Cement Association
Witco Chemical Company
American Society of Agricultural Engineers
Borg-Warner

Applications of the Association of American Railroads and the Ontario Professional Engineers were held pending further inquiry.

Code of Ethics and Oath

A proposal from Dean Trezise to establish in engineering colleges a practice of administering an oath to engineering students, similar to the Hippocratic oath for medical students, was discussed. The opinion was expressed that there is a trend in modern times away from ritualistic ceremonies and it was questioned as to whether the students would regard this in the same solemn sense that doctors regard the Hippocratic oath. No action was taken.

The Executive Board expressed the opinion that the Canons of Ethics might be used to better advantage in all engineering colleges and recommended that Dean Freund consider the possibility of urging the deans of engineering colleges to post these on bulletin boards and give reprints to all students either at the freshman or senior level. The suggestion was also made that ECPD consider the possibility of mailing the Canons of Ethics without charge to all engineering freshmen or seniors.

ASEE Branch at Purdue University

A petition from Purdue University for an ASEE Branch was approved by the Executive Board.

Associate Membership Drive

The Executive Board voted to send Mr. Jesse McKeon, Chairman of the ASEE Committee on Associate Institutional Membership, an expression of appreciation for the excellent job of handling the Society's Associate Institutional Membership Drive and congratulations on having passed the goal of 100 Institutional Members.

ECAC Salary Study

Consideration was given to the advisability of ECAC conducting a study of faculty salaries. There have been numerous requests for this information and individual schools are beginning to send out questionnaires to collect these data. It was estimated that the cost of such a salary study would be of the order of $1,000. This was referred to ECAC for further consideration.

Request for Division of Nomography

A request for a Division of Nomography in the ASEE was rejected, with the recommendation that the matter be referred to the Division of Engineering Drawing.

Respectfully submitted,
ARTHUR BRONWELL,
Secretary

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	University of Pittsburgh	April 30–May 1, 1954	W. I. Short, University of Pittsburgh
Illinois-Indiana	Illinois Institute of Technology	May 15, 1954	R. G. Owens, Illinois Institute of Technology
*Kansas-Nebraska	University of Nebraska	Fall, 1954	M. H. Barnard, University of Nebraska
Michigan	University of Michigan	May 8, 1954	F. L. Schwartz University of Michigan
Middle Atlantic	Lafayette College	May 8, 1954	H. M. Jenkins, Swarthmore College
Missouri-Arkansas	Missouri School of Mines	April 10, 1954	V. J. Blum, St. Louis University
National Capital Area	Catholic University	May 8, 1954	C. H. Walther, George Washington University
New England	Massachusets Institute of Technology	Oct. 9, 1954	E. R. McKee, University of Vermont
North Midwest	Michigan College of M. and T.	Oct. 8–9, 1954	C. J. Pratt, Michigan College of M. and T.
Ohio	Ohio State University	May 1, 1954	R. S. Paffenbarger, Ohio State University
Pacific Northwest	Oregon State College	April 23–24, 1954	L. Slegel, Oregon State College
Pacific Southwest	California Institute of Technology	Dec. 28–29, 1954	B. M. Green, Stanford University
Rocky Mountain	University of Utah	May 14–15, 1954	A. Diefendorf, University of Utah
Southeast	North Carolina State College	March 25–27, 1954	J. R. Cudworth, University of Alabama
Southwest	University of Texas	April 16–17, 1954	J. J. Heimerich, University of New Mexico
Upper New York	Cornell University	Oct. 22–23, 1954	N. A. Christensen, Cornell University

Members of the Society are welcome at all Section Meetings

* No Date Set.

New Members

ANDERSON, A. MELCHER, Manager of Technical Education, General Electric Company, Room 300, Building 23, 1 River Road, Schenectady, N. Y. M. M. Boring, D. S. Roberts.

APPLETON, GLENN R., Instructor in Mechanical Engineering, South Dakota State College, Brookings, South Dakota. D. H. Madsen, L. L. Amidon.

ARMENTROUT, PETER C., Engineering Training Supervisor, Boeing Airplane Company, Seattle, Washington. V. M. Ganzer, H. E. Wessman.

ARNOLD, ROBERT G., Instructor in Engineering Drawing, University of Wyoming, Laramie, Wyo. A. J. McGaw, F. L. Spenner.

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645 new members elected this year

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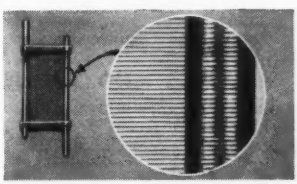

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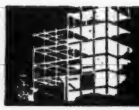

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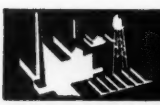
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